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of the
American Association *of* Petroleum Geologists

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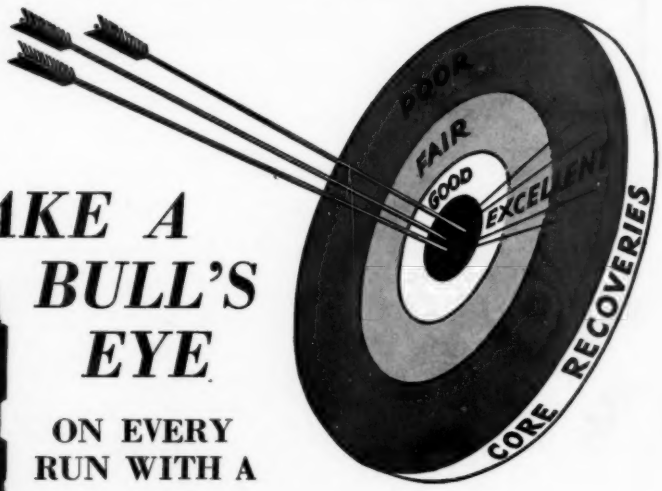

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THE BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS is published by the Association on the 15th of each month. Editorial and publication office, 608 Wright Building, Tulsa, Oklahoma. Post Office Box 979. Cable address, AAPGEOL.

THE SUBSCRIPTION PRICE to non-members of the Association is $15.00 per year (separate numbers, $1.50) prepaid to addresses in the United States. For addresses outside the United States, an additional charge of $0.40 is made on each subscription to cover extra wrapping and handling.

British agent: Thomas Murby & Co., 1 Fleet Lane, Ludgate Circus, London, E. C. 4.

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Entered as second-class matter at the Post Office at Tulsa, Oklahoma, and at the Post Office at Menasha, Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized March 9, 1923.

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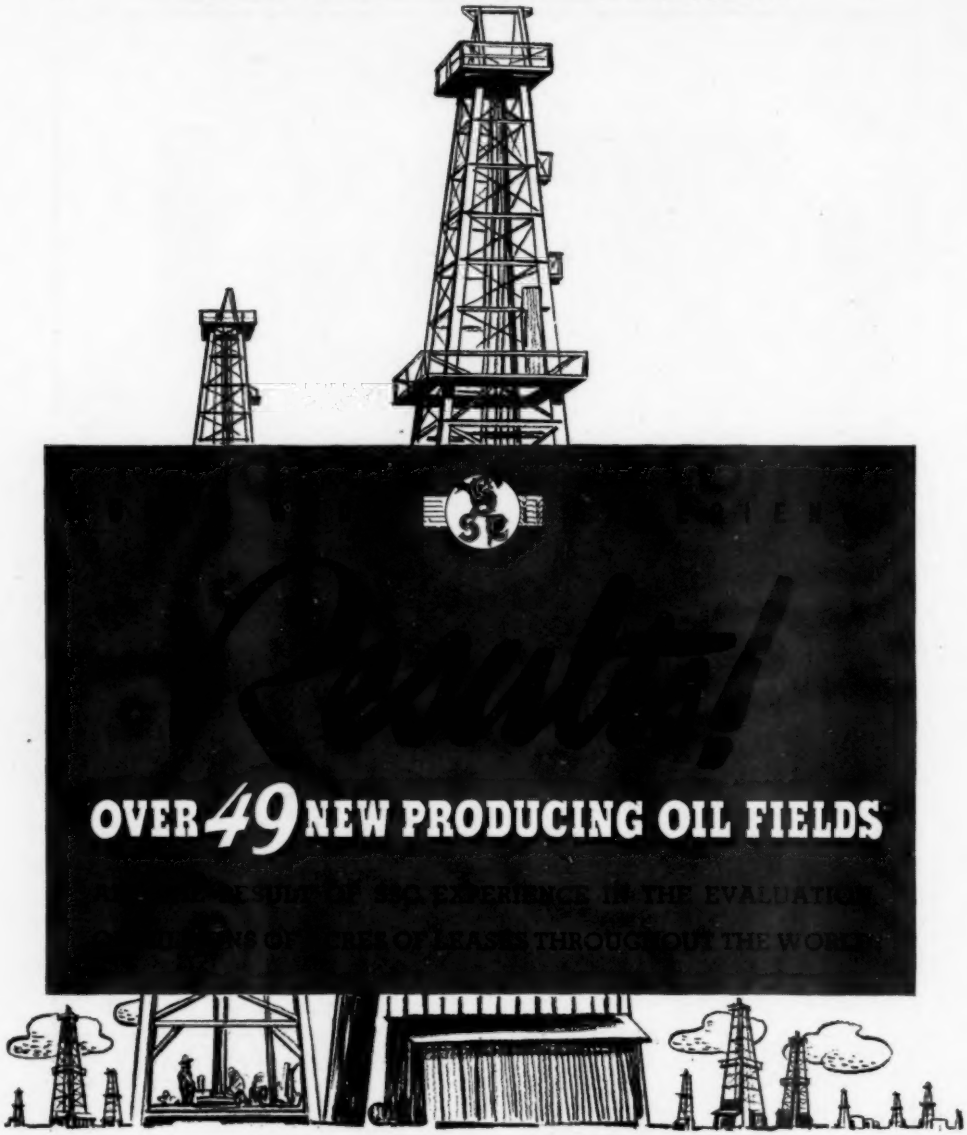

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By Henry Rogatz

Geology of Hugoton Gas Field of Southwestern Kansas

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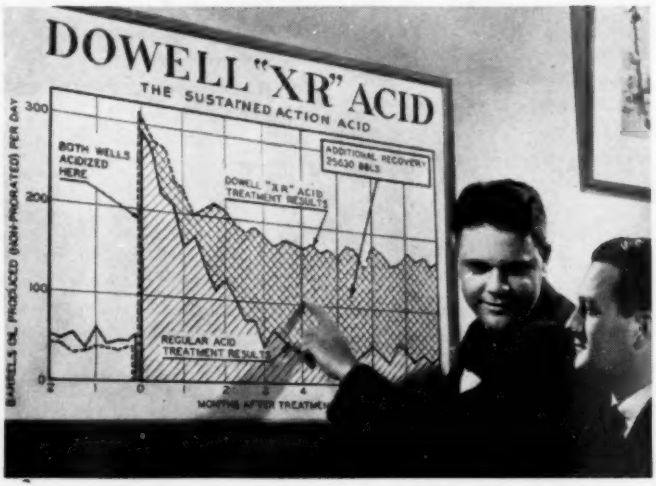

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Volume 23 Number 6

BULLETIN
of the
AMERICAN ASSOCIATION OF
PETROLEUM GEOLOGISTS

JUNE, 1939

THE RELATION BETWEEN CRUDE OIL AND PRODUCT PRICES[1]

SIDNEY A. SWENSRUD[2]
Cleveland, Ohio

The relation between crude oil and refined product prices has long been a source of discussion within the petroleum industry and particularly since the inauguration of proration. When refined product prices have receded during times of over-supply or falling off in consumption, independent refiners have contended that they were the victims of a semi-fixed price of crude which did not similarly respond to the downward forces or at least not soon enough to avert serious trouble for refiners. Crude oil producers, on the other hand, tend to place the blame for reduction in refined product prices entirely upon alleged mistakes within the refining branch and contend that if refiners would reduce their runs more effectively accumulation of surplus stocks would be avoided and prices would hold. According to their view, prices of refined products should follow the price of crude and not vice-versa—at least when they are being lowered. The producers say that during times of reduced refinery prices, crude price reductions would merely cause further reductions in refined product prices and so on, until ruinous levels resulted. The other view is that refined price changes naturally occur ahead of crude price changes because of the more sensitive nature of the refined product markets but that changes in refined product prices are not a primary cause of changes in crude, or vice-versa; rather both crude oil and product price changes fundamentally are the result of changes in the supply-demand relationships for the industry as a whole. There are, therefore, two main questions.

[1] Read before the Association at Oklahoma City, March 23, 1939.

[2] Assistant to the president, The Standard Oil Company (Ohio).

1. What are the facts as to the relationship existing, from time to time, between the price of crude oil and the value of the refined products produced therefrom?

2. What is the sequence in crude oil and product price movements?

Table I below shows by years from 1920 through 1938 the average wholesale market value at the refinery of the products typically produced at Mid-Continent refineries from typical Mid-Continent

TABLE I

	Average Wholesale Value of Typical Refined Products from 1 Barrel of Mid-Continent Crude	*Average Price per Barrel of 36° Gravity Mid-Continent Crude at the Well*	*Refining Margin. Amount Available for Refining and Crude Transportation*
1920	$4.74	$3.42	$1.32
1921	2.50	1.65	.85
1922	2.83	1.68	1.15
1923	2.21	1.56	.65
1924	2.12	1.64	.48
1925	2.51	1.87	.64
1926	2.69	2.13	.56
1927	1.80	1.38	.42
1928	1.94	1.31	.63
1929	1.87	1.37	.50
1930	1.58	1.23	.35
1931	.98	.63	.35
1932	1.24	.87	.37
1933	1.10	.62	.48
1934	1.37	1.00	.37
1935	1.55	1.00	.55
1936	1.69	1.10	.59
1937	1.76	1.22	.54
1938	1.57	1.18	.39

crude. The yields of the different products were taken from the reports to the U. S. Bureau of Mines by refineries in the Oklahoma, Kansas, and Missouri, Texas Inland, and Arkansas and Louisiana Inland districts. To the yields of each product were applied the Oklahoma refinery wholesale prices for each product, these prices being obtained from the trade journal sources. The aggregate wholesale value of the refined products from a barrel of crude on the basis of the aforementioned yields and prices is shown in the first column. In the second column is shown the average well price for each year of 36° gravity Oklahoma crude and the difference between the two (shown in the third column) is the amount available for getting the crude oil from Mid-Continent wells to Mid-Continent refineries and doing the refining. The detailed monthly data back of the summary figures are

shown in the appendix. An example of the computations for the month of June, 1935, is as follows.[3]

Products	*Yield*		*Oklahoma Wholesale Refinery Price per Gallon*	*Value*
	Per Cent of Crude	*Gallons per Barrel of Crude*		
Gasoline	50.24	21.10	$.05625	$1.19
Kerosene	6.49	2.73	.0400	.1092
Gas and heating oils	9.82	4.12	.0325	.1339
Fuel oil and still gas	28.23	11.86	.016369	.1941
Miscellaneous	2.02	.85	.0230	.0196
Loss, etc.	3.20	1.34	—	—
Totals	100.00	42.00		$1.65
Well price of 36° gravity Mid-Continent crude				1.00
Margin				$ .65

In Figure 1, the data for total refinery value of products produced from one barrel of crude and the well price of 36° gravity crude are shown graphically by months from 1920 through 1938. Figure 2 portrays in graphic form the amount of the refining margin between the value of products and the price of crude.

The data presented in Table 1 and Figures 1 and 2 show how the value of products, the price of crude, and the refiner's margin have varied from time to time during the last 19 years. These years cover a wide variety of circumstances both as to the fundamental facts of supply and demand of petroleum products and the degree of artificial control obtaining.

The year 1920 marked the close of the post-war period of extremely high prices both of crude and products. The year 1921 witnessed the discovery of important crude fields in Los Angeles which, together with the industrial depression of that year, changed the supply-demand situation for the petroleum industry rather suddenly. Thereafter, until 1927, the industry was in a period of extremely rapid growth and rather wide fluctuation in crude oil and refined prices varying with the supply-demand situation. In 1926 came the discovery of the Seminole field and the following year, 1927, is usually assigned as the year in which proration began. So far as the question of artificial control of supply is concerned we may, therefore, consider 1927 as the dividing line between the period of free competition and

[3] Approximately the same data were presented, beginning with the year 1928, in the July 13, 1938, issue of the *National Petroleum News*, pp. 25, 26, and 28. That magazine now publishes a so-called Refinery Index figure in an early issue of each month. In this paper, however, the computations have been carried back on a monthly basis to the year 1920.

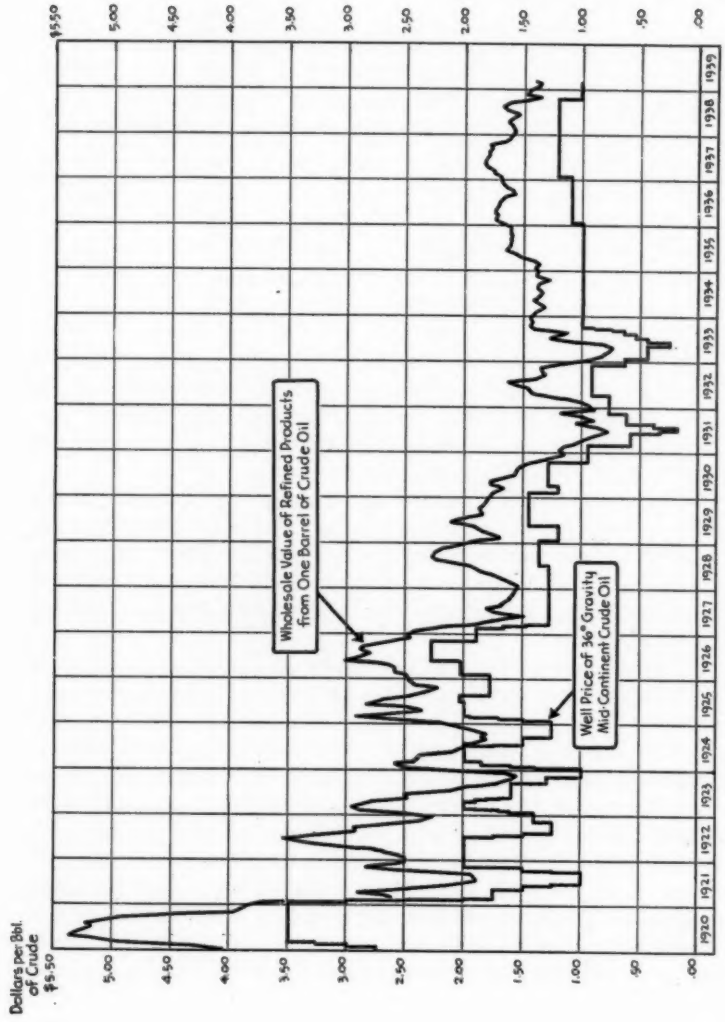

FIG. 1.—Crude oil price and wholesale value of refined products.

the period when artificial restrictions of one sort or another were imposed. As may be noted from Figure 1, the average price trend has been downward throughout most of the whole period since 1920.

We are less interested here, however, in the question of the general price levels prevailing from time to time than in the *relationship* between the price of crude oil and the value of refined products. This relationship is best measured by the difference between the two values as shown in the third column of Table 1 and as set forth graphically in

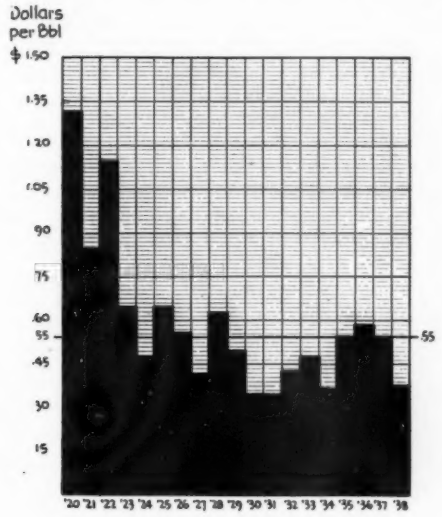

FIG. 2.—Refinery margin.

Figure 2. It will be noted that this difference, which we may refer to as the refining margin, has varied extremely from time to time—from a high of $1.32 a barrel in 1920 to a low of 35 cents in 1930 and 1931—from 59 cents a barrel in 1936 to 39 cents a barrel in 1938.

We do not know just what the costs are which must be covered by the margins in question—the operation consists of getting the crude from Mid-Continent wells to Mid-Continent refineries and doing the refining job to make the products indicated. Since the price quotations we are using are for refineries in the Oklahoma area, it can be assumed that the crude oil transportation is essentially a gathering operation in most cases, the cost of which, for the average refinery involved, would average about 10–15 cents a barrel. Refining expenses have doubtless increased during the period as gasoline yield has risen

and increased cracking operations have been involved and also as the quality of the gasoline produced has been improved. On the other hand, various economies in the use of fuel and a higher degree of automatic operation have been attained which should offset, to some extent, increasingly complicated processing operations. Wage rates, of course, have risen substantially. It has been estimated that at least 40–45 cents per barrel of crude probably has been required during the last eight or ten years to cover the refining costs involved in making the products indicated. On this basis, a total of about 55 cents a barrel on the average would seem to be a fair approximation of the total crude transportation and refining expenses involved. This does not assume the inclusion of a figure for interest on the investment which, as may be seen from the Government figures in footnote 4, would add a substantial amount per barrel.[4]

On the basis of 55 cents a barrel representing the costs involved, it appears that until 1927 refining was a profitable activity, on the average, for each of the years shown but that during the period since the beginning of 1927, refining has been able to stand on its own feet,

[4] A report (No. 30) of the U. S. Tariff Commission, issued March 3, 1939, showed refining costs per barrel of crude as follows.

	1929	*1930*
Atlantic Coast Refineries		
Exclusive of interest	$.64	$.62
Interest	.11	.11
Total	.75	.73
Gulf Coast Refineries		
Exclusive of interest	.45	.49
Interest	.08	.08
Total	.53	.57
California Refineries		
Exclusive of interest	.26	.28
Interest	.05	.06
Total	.31	.34
Mid-Continent Refineries		
Exclusive of interest	.4317	.4779
Interest	.0597	.0647
Total	.4914	.5426
Ohio Valley Refineries		
Exclusive of interest	.5911	.6126
Interest	.0946	.1004
Total	.6857	.7130

The departmental figures submitted by the Humble Oil and Refining Company to the so-called Cole Committee's petroleum investigation (see Page 2823, Hearings—House Resolution 441, 1934) showed refining losses in the years 1931, 1932, and 1934. During these years the Oklahoma refining margin, as shown in Table I, was 35¢, 37¢, and 37¢ per barrel, respectively. For 1933, a profit before overhead expenses was shown—in that year the Oklahoma refining margin figure was 48¢.

on the basis of full posted crude oil prices, in only three out of the twelve years involved, namely, 1928, 1935, and 1936, although in 1937 the margin stood at 54 cents, or approximately at the break-even point. On the average, from 1920 through 1926, the refining margin was 81 cents a barrel. From 1927 through 1938, it was 46 cents a barrel.

An examination of the refining margin by monthly or by quarterly periods reveals extremely sharp fluctuations from period to period, indicating the rapidity with which the refining situation can change as the relationship between crude oil and product prices shifts. A reduction in the refining margin has generally come about, in the first instance, through refined product prices declining from earlier levels without a corresponding decline in the crude oil price. Of course whenever the crude oil price increases, the refining margin is narrowed but, as is shown in the following paragraph, crude oil price changes commonly follow product price changes, so that when a crude oil price increase takes place, it is generally after there has been some improvement in the refining margin.

SEQUENCE OF CRUDE OIL AND PRODUCT PRICE CHANGES

A careful examination of the relationship between crude oil and product prices indicates beyond a doubt that changes in product prices precede changes in crude oil prices and not vice-versa. There has scarcely ever been a change in the price of crude, either up or down, which was not foreshadowed by a preceding change in the same direction in the wholesale value of the refined products. This may be seen in Figure 1; it will be noted, however, that the time lag of crude price changes behind product price changes is greater on the down side than on the up side. In other words, the crude oil price follows refined product price *increases* much more promptly than it follows product price declines. An examination of the timing of Oklahoma wholesale gasoline price changes, for example, and Mid-Continent crude oil price changes since 1924 showed that, on the average, the crude oil price declined approximately 6 months after declines in gasoline prices had begun. During the same period, the crude price increased on the average within 3 or 4 months after improvements in gasoline prices began.

REASON WHY CRUDE OIL PRICE CHANGES LAG

It is not intended in the foregoing discussion of crude oil and product price sequence to suggest that crude oil price changes are *caused* by product price changes. It is the writer's belief that the same

causes are involved in both crude oil and product price changes for, except in a superficial sense, there is only one set of supply-demand factors in the oil industry in the United States; namely, the supply of crude oil and the demand for refined products. There is no demand for crude oil except to make it into products and no supply of products except crude oil—except in rare cases, such as a sudden increased demand for a particular product in a quantity greater than can be manufactured at once (as appears to have been the case with gasoline during a part of 1928) or a sudden decline in demand for a by-product which it is difficult to discontinue manufacturing at once (such as the decline in the demand for industrial fuel oil in 1938).

As to whether the price of raw materials or their manufactured products, in general, tend to move first we do not believe any generalization for industry as a whole can be made; rather we believe it depends on the nature of the markets involved. The price of iron ore changes very infrequently. On the other hand, the leading raw materials in the food and textile industries, namely, wheat and cotton, change from moment to moment in the great central exchanges where these products are traded.

So far as the petroleum industry is concerned, it is obvious, we believe, that the refined product markets are much more promptly sensitive to supply and demand than is crude oil, under ordinary circumstances. This was pointed out in the report of the Petroleum Code Survey Committee with respect to the N.R.A. period when the wholesale price of gasoline fluctuated up and down in a range of 3.5 cents to 5 cents a gallon in response to rapidly shifting prospects for crude oil production control while the crude oil price itself remained unchanged throughout the period.[5]

[5] "While at all times since the Code there has therefore been over-production of crude oil as compared with the allocations, there have in addition been many intermediate changes in the outlook with respect to crude oil control. In February, 1934, for example, the Government's powers under the Code were greatly reduced by the decision of Judge Bryant in the Panama and Amazon cases (see Exhibit I). In the week following his decision the wholesale price of gasoline in Oklahoma declined approximately .5 cents a gallon, which in terms of crude oil would be equivalent to 10 to 12 cents a barrel. In April new Federal oil legislation was proposed and late in that month the Thomas-Disney Bill was introduced, strongly backed by the Administration and a large part of the industry. There appeared little doubt that it would pass and that strong Federal control would thus be restored. The price of gasoline reflected these changes in prospect, and from early April through May it rose approximately .75 cent a gallon. By the second week in June, however, it became evident that the Thomas-Disney Bill would not be enacted. Here again was another shift in the outlook, and the price of gasoline, evidently reflecting it, declined in mid-June by approximately .5 cent a gallon. As the summer progressed the hot oil flow from East Texas increased and correspondingly the gasoline price structure steadily weakened. For a time a distinction was made in the price quotations between legal and illegal gasoline and the full effect of the hot oil and gasoline from East Texas can be understood only by examining the prices at which the hot gasoline was being sold. By the middle of October,

Clearly, the gasoline price fluctuations during that period were not primarily in response to the current rates of gasoline production or the stocks of gasoline on hand, which did not undergo any sudden or drastic changes concurrent with the price changes referred to.

The reason refined product prices are more sensitive is doubtless the fact that trading is continually going on in these markets and price changes occur in minute fractions of a cent per gallon. Many sellers meet or contact many buyers almost continually, and there is no physical obstacle, such as a pipe line, to stand in the way of a buyer shifting from one source of supply to another or to hinder a seller from changing customers so far as wholesale transactions are concerned. Contrast this with the mechanics of the crude oil market where, under ordinary circumstances, buyers and sellers are closely associated together by pipe-line connections. (Where this is not the case, as in a flush pool where oil is being shipped in tank cars, trucks, *et cetera*, crude oil prices frequently fluctuate widely during short periods.) These close physical connections between crude producer and purchaser make for delays in price changes because, in a competitive industry, price changes ordinarily come about through a buyer shifting or threatening to shift from one seller to another or vice-versa. In the case of crude oil producers and purchasers bound together by pipe-line connections, however, there is difficulty and inconvenience in producers shifting to new purchasers or purchasers shifting to new sources of supply. In other words, there is the element of inertia. Furthermore so far as crude price *declines* are concerned, there is the fact that the initiative ordinarily comes from the purchasers in that they usually post their purchase prices. For the buyer to cut the crude price is, therefore, to take upon himself considerable ill will, however justified his action might be from the standpoint of supply and demand. This is in sharp contrast to the impersonal nature of the similar transactions in connection with commodities such as wheat or cotton, where there is no close physical or personal relation between the ultimate buyer and the producer.

These aspects of the crude oil price market explain, we believe, why

however, even legal gasoline had sunk more than 1 cent a gallon from the midsummer level. Crude, however, still remained at $1.00 a barrel. Then late in October came the creation, under Section 9 (c) of the National Industrial Recovery Act, of the Federal Tender Board which was set up to make effective the prohibition of interstate shipments of illegal crude oil and products from East Texas. The new Board was successful immediately in drastically reducing such shipments. Here was perhaps the most definite example of all of a sudden change in the supply picture, and the gasoline price, sensitive to it, suddenly reversed its downward trend and advanced sharply for about two weeks, recovering from the extreme lows of October."

Report of Petroleum Code Survey Committee to Secretary of Interior Ickes, March 28, 1935.

it is a rather sluggish market in responding to changes in the supply-demand situation which have already been reflected in the prices of refined products. It must be admitted, however, that they are hardly sufficient to explain the length of some of the time intervals between crude oil price changes in recent years, and we believe this tendency toward fixity must be partly attributed to proration rather than to the fundamental nature of the crude oil market.

We have already observed the way in which the wholesale gasoline price tends to reflect changes in the basic supply-demand situation

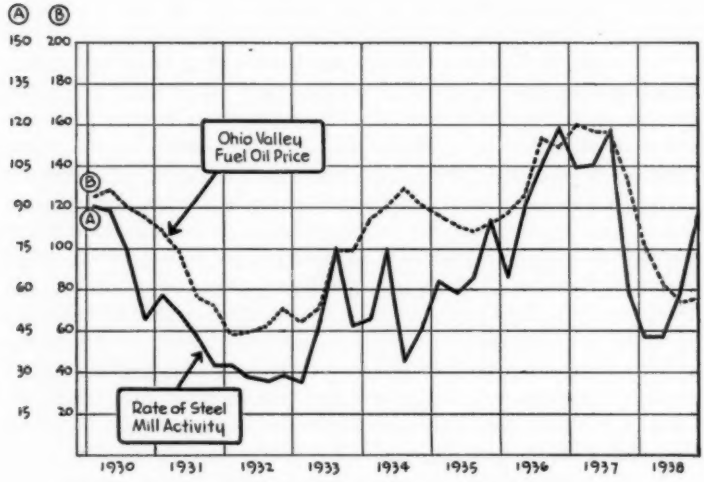

FIG. 3.—Ohio Valley fuel oil price and rate of steel mill activity.

for the industry as a whole. Generally speaking, it probably is safe to say that for the industry as a whole demand is the more stable part of the equation, the main fluctuations being in regard to the supply factor. Quite the opposite is true, however, as to heavy fuel oil which is essentially a by-product depending largely on the rate of industrial activity for its demand. It is interesting to note the close relationship between the price of fuel oil and the rate of industrial activity. This may be observed in Figure 3 which compares the rate of steel mill activity with the price of heavy fuel oil in the Ohio Valley. The fuel oil prices are shown as a percentage of the average through a period of years and are from a private source.

RELATIONSHIP BETWEEN GASOLINE AND CRUDE OIL PRICE

One of the provisions of the Petroleum Code under the N.I.R.A. was the suggestion that the price of crude oil should be established on the basis of the wholesale value of 18.5 gallons of regular grade gasoline. Considerable interest has centered around this idea ever since and it is interesting to examine in more detail the relationship that has actually existed between the price of crude oil and the price of gasoline during the period covered in this study, namely, 1920 through 1938. The average gasoline and crude prices by years are shown in Table II. The gasoline prices are the same as used in the

TABLE II

Year	*Average Oklahoma Wholesale Price per Gallon of Regular Grade Gasoline*	*Average Well Price per Barrel of 36° Gravity Mid-Continent Crude Oil*	*Number Gallons of Gasoline Required to Purchase 1 Barrel of Crude*	*Yield of Gasoline from Crude (gals. per bbl.)**
1920	$.2124	$3.42	16.1	12.81
1921	.1377	.165	12.0	13.90
1922	.1430	1.68	11.7	14.83
1923	.0992	1.56	15.7	15.41
1924	.0898	1.64	18.3	15.79
1925	.1057	1.87	17.7	17.05
1926	.1035	2.13	20.6	17.60
1927	.0672	1.38	20.5	18.06
1928	.0782	1.31	16.8	18.22
1929	.0759	1.37	18.1	18.04
1930	.0603	1.23	20.4	19.82
1931	.0358	.63	17.6	20.52
1932	.0452	.87	19.2	21.07
1933	.0381	.62	16.3	20.85
1934	.0460	1.00	21.7	21.01
1935	.0528	1.00	18.9	21.10
1936	.0586	1.10	18.8	21.16
1937	.0581	1.22	21.0	21.54
1938	.0500	1.18	23.6	22.00 (est.)

* Okla., Kan., Mo.; Texas Inland; and Ark. and La. Inland Districts, as per Bureau of Mines Reports.

computation of Table I, being the monthly averages of the low Oklahoma wholesale refinery prices of the type of gasoline which appears to have been the leading "regular" grade from time to time. (See Appendix.) In the third column at the right is shown the average number of gallons of gasoline required in each year to cover the cost at the well of one barrel of 36° gravity Mid-Continent crude.

It appears from the figures above and from Figure 4 that an increasing number of gallons of gasoline has been required to purchase one barrel of crude. To a considerable extent the reason for this, of course, is the fact that the gasoline yield from crude has been increasing as shown in Table II and Figure 4. In addition, however, it would appear that the phenomenon is a part of the general narrowing of the

refining margin which has already been referred to. Not for a single year since the 18.5 ratio was set forth in the Petroleum Code has the refiner been able to buy his crude oil on that basis; it has invariably cost him more.

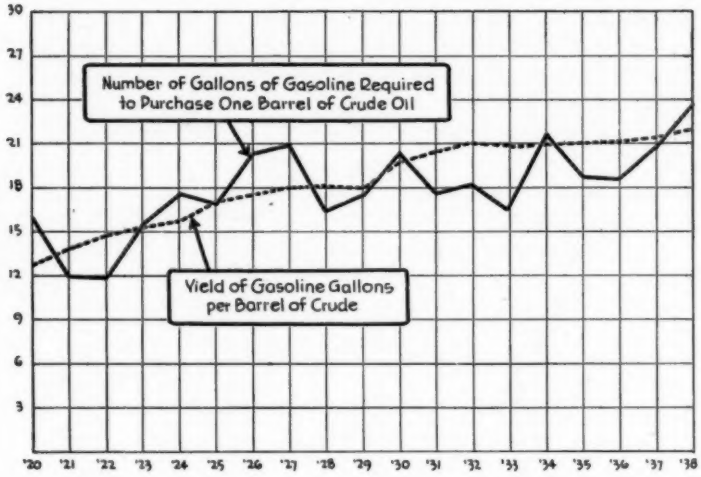

FIG. 4—Relationship between gasoline and crude oil price.

WHAT IS THE REASON FOR NARROWING OF REFINING MARGIN?

The purpose of this paper is primarily to present facts as to the relation between crude oil and refined products rather than to argue any particular thesis. It will be interesting, however, to mention briefly some of the explanations that have been suggested of the growing tendency of the refining margin to be narrowed severely from time to time. One frequent suggestion is that refiners are prone to over-produce even though crude oil production and stocks are in apparent balance with demand. This theory may seem to presuppose, however, that refining is done by a different class of people from those who are engaged in other parts of the industry, whereas in fact most refining is done by integrated companies in which refining is under the same general management as other branches. There is no question, of course, but that excessive stocks of refined products are a price-depressing factor. It may be questioned, however, whether any large excess of refined products generally does not indicate either a slowing down in demand or an increasing pressure of crude oil or both of these

factors rather than purely a tendency of refiners to over-run for the sake of increasing their throughput. Certainly during most periods when there has been accumulation of refined product stocks, it could not be denied that one or both of these other factors has been present. It must be remembered that an increasing pressure of crude oil, for example, need not be always reflected in rising crude oil stocks. The fact that there is great excess capacity to produce a given product and a desire on the part of the owners of that capacity to utilize it is, we believe, sufficient to establish pressure of supply upon the market in the economic sense in which supply affects price. In the oil industry, the highly integrated character of a large part of the operation makes it possible for the pressure of crude to be exerted directly upon the refined product markets. Indeed if every oil company had all of its own production, then, barring prices paid to royalty owners, there would be little occasion for changes in the crude oil price, for supply and demand would then be expressed almost entirely in refined product prices. This is somewhat the situation in the iron and steel industry where most of the important manufacturers have their own ore mines. Perhaps the increasing degree of integration in the oil industry is an important factor in explaining the narrowing of the refiner's margin; in other words, as a smaller proportion of the total crude production has "to go to market" in the true sense, on account of more refiners having their own production, the price may tend to become less realistic. For the integrated company having all or nearly all of its own production, it is essentially academic whether it makes a refining profit, as such, or not—its real interest is in the over-all margin between its crude oil production cost and its ultimate realization for all products. In establishing its refined product prices, therefore, it can ignore the posted price of crude if it chooses and consider only its production costs. This aspect of integration has been advanced as one of the reasons why the crude oil price appears to have become less responsive to changes in the supply-demand picture than formerly and in all probability it has been one of the factors.

In somewhat the same connection, it is suggested that there is a tendency under proration and integration for the refining margin to narrow. The argument is that proration, being essentially a political mechanism, must undertake to maintain the crude oil price at a level high enough to satisfy the large number of independent crude oil producers, especially those who depend on settled or stripper production. Such a price level, however, is bound to be far above the actual production costs of the average barrel of crude and particularly of the additional crude which could be produced by particular com-

panies anxious to increase the volume of their operations. As a result, such companies are willing to sell refined products on the basis of production costs considerably below posted price levels and thus refined product prices are constantly being borne down to levels tending to correspond to production costs whenever these are below posted prices.

RELATIONSHIP AMONG VARIOUS REFINED PRODUCT PRICES

There is a fairly close relationship between the price trends of the various refined products; that is, they generally move in the same direction at the same time although the proportionate amount of change varies substantially as among the different products. Kerosene prices, for example, tend to be more stable than gasoline prices, and residual fuel oil prices less so. There have been a few occasions when gasoline price has been increasing and prices of certain other products declining and vice-versa but in the course of any considerable length of time the price trends of almost all the refined products have generally been in the same direction. This is to be expected because within certain limits the proportions of the different products made can be varied somewhat. If one product is relatively high in price, refiners make every effort to make more of that product and less of others. The year 1937 is an example of a year when a substantial improvement in the realization from products other than gasoline took place without any improvement in gasoline prices. This undoubtedly was because the high rate of industrial activity during most of that year created an excellent demand for fuel oil and other industrial products.

SUMMARY AND CONCLUSION

This study of the relationship between crude oil and refined product prices calls attention once more to the strong downward trend of petroleum prices and operating margins which has been going on for many years. In large part, it reflects the improvements that have been achieved in production, transportation, and refining, but it probably reflects, too, a tendency toward declining profits as the industry matures and the rate of growth lessens. The market value of the refined products of crude oil has, however, declined considerably more than the raw material itself. In the period since the beginning of 1927, the wholesale value of the refined products from a barrel of crude declined by an average of $1.26 a barrel as compared with the period from 1920 to 1927. Between the same periods, the price of crude declined by an average of 92 cents a barrel.

Thus it is apparent that the price relationship between crude oil

and refined products has undergone a considerable change during the period covered by the study, in that in the period since 1927 the products of a barrel of crude have shrunk by 34 cents a barrel more than has the posted price of the raw material from which they are obtained. It is to be borne in mind, also, that with the increased yield and quality of gasoline, the products of a barrel of crude to-day are relatively a more valuable combination requiring more refining operations than the combination of products made in the early part of the '20's. So far as refining is concerned, there would seem to be nothing abnormal or alarming in the fact that the refining margin declines from time to time to unprofitable levels for it is not the nature of the competitive system to permit comfortable and profitable operation of an industry all the time. It must be remembered that one of the functions of price is to act as a stimulant or a deterrent to the inflow of new capital and at times the refining capacity, relative to requirements, is such that there is little need for new capital. Likewise, there is nothing abnormal in the fact that the prices of refined products, being more sensitive, should reflect changes in the supply-demand situation for the industry as a whole more promptly than do crude oil prices. On the other hand there appears, in recent years, to have been an abnormal degree of postponement in the response of crude oil prices to adverse changes in the supply-demand picture for the industry as a whole and this tendency has operated to the serious disadvantage of the refining branch of the industry. Some authorities question whether it would not be more advantageous for the industry as a whole if there were a closer correspondence between the movements of crude oil and refined product prices. Certainly it must be admitted that if we are to have a free-enterprise industry, declines as well as improvements in the market prices of our industry's products and its raw material must take place from time to time.

Of course, the crude oil price can not indefinitely remain unresponsive to changes in the market value of its products, a fact which was borne out in 1938 when approximately a year after the decline in refined product prices began, there was a general decline in crude oil prices. If independent refining is to survive as a separate activity along with independent production and marketing, however, there must be a reasonably prompt response in the raw material prices to fundamental changes in petroleum supply and demand and the time lag on the down side must not be too greatly in excess of the lag on the up side when refined prices are rising. It is understandable, of course, that crude oil producers do not like to see crude oil prices decline any more than refiners like to see product prices decline. In

a time when excesses are accumulating, however, whether they be in actual above-ground stocks, the discovery of new reserves, or the drilling of new wells or other increases in production capacity, some reduction in price may be one of the necessary corrective factors before a genuine improvement can ensue and it may well be that more prompt changes in smaller amounts might be salutary. The industry has achieved, in the last several years, a greater stability in the general range of crude oil prices which seems entirely healthy but, at the same time, the time lag on the down side has been increasing. It is quite possible, as Mr. Byles, president of the American Petroleum Institute, suggested in his address at Houston, Texas, in 1934, that a small reduction in the price made promptly would avert the necessity of a much greater change later when the pressure of over-supply or over-capacity had been unduly aggravated by the delay. There is always the fear on the part of the producers, of course, that once a decline sets in it will lead to ruinous levels. Barring special situations such as East Texas in 1931, however, and especially under to-day's proration conditions, this fear hardly seems justified by the facts. It is perhaps significant to note that within a few months after the recent decline in the crude price, an improvement in refined product prices has commenced.

APPENDIX

PRICE DATA

	*Oklahoma Refinery Tank Car Market**				*Price in Dollars per Barrel*		
	Cents per Gallon						
Date	*Gasoline*	*Kerosene*	*Gas Oil*	*Fuel Oil*	*Price at Well Crude Oil*	*Total Value of Refined Products†*	*Refining Margin*
1920							
	58–59° Grav. 430–440 E.P.	42–43° Grav.	32–36° Grav.	24–26° Grav.	36° Grav.		
Jan.	17.313	11.250	7.125	5.269	2.96	4.05	1.09
Feb.	19.438	11.688	7.188	5.133	3.02	4.33	1.31
Mar.	21.550	12.200	8.900	6.662	3.50	4.95	1.45
Apr.	22.313	12.031	9.750	7.352	3.50	5.19	1.69
May	22.875	11.625	9.750	8.186	3.50	5.37	1.87
June	23.450	11.650	8.200	7.773	3.50	5.29	1.79
	58–60° Grav. 430–440 E.P.						
July	23.250	11.156	8.250	7.446	3.50	5.19	1.69
Aug.	23.100	10.575	8.625	7.950	3.50	5.23	1.73
Sept.	22.750	10.063	7.750	6.738	3.50	4.93	1.43
Oct.	20.875	9.313	6.688	5.786	3.50	4.45	.95
Nov.	18.900	8.750	5.725	4.774	3.50	3.95	.45
Dec.	18.500	8.969	5.595	4.300	3.50	3.85	.35
AVERAGE	21.236	10.770	7.813	6.471	3.42	4.74	1.32

* Prices of gasoline are the averages of the low quotations. Prices of all other products are the averages of the high and low quotations.

† Wholesale value of typical refined products from one barrel of Mid-Continent crude oil.

Date	Oklahoma Refinery Tank Car Market* Cents per Gallon Gasoline	Kerosene	Gas Oil	Fuel Oil	Price in Dollars per Barrel Price at Well Crude Oil	Total Value of Refined Products†	Refining Margin
1921	58–60° Grav. 430–440 E.P.	42–43° Grav.	32–36° Grav.	24–26° Grav.	36° Grav.		
Jan.	18.200	8.525	4.664	3.286	3.35	3.70	.35
Feb.	14.063	5.423	2.469	1.577	1.88	2.60	.72
Mar.	14.688	4.485	2.594	1.801	1.75	2.66	.91
Apr.	16.313	4.344	2.656	1.786	1.75	2.90	1.15
May	14.063	3.344	2.173	1.429	1.51	2.46	.95
June	12.650	2.500	1.664	1.083	1.18	2.13	.95
July	11.313	2.141	1.255	.952	1.00	1.88	.88
Aug.	11.250	2.227	1.315	1.071	1.00	1.90	.90
Sept.	11.250	2.516	1.488	1.211	1.01	1.94	.93
Oct.	13.350	4.188	2.700	2.048	1.48	2.52	1.04
Nov.	14.750	5.126	3.174	2.367	1.90	2.83	.93
Dec.	13.313	4.114	2.625	2.024	2.00	2.50	.50
AVERAGE	13.774	4.099	2.389	1.731	1.65	2.50	.85
1922	58–60° Grav. New Navy 437 E.P.	41–43° Grav. Prime White					
Jan.	12.900	3.501	2.389	1.964	2.00	2.50	.50
Feb.	13.575	3.455	2.455	2.262	2.00	2.65	.65
Mar.	13.875	3.473	2.674	2.030	2.00	2.68	.68
Apr.	15.250	3.376	2.814	1.994	2.00	2.87	.87
May	17.500	3.976	3.126	2.117	2.00	3.27	1.27
June	18.750	4.595	3.050	2.545	2.00	3.54	1.54
July	17.438	4.251	2.846	2.411	1.75	3.31	1.56
Aug.	14.450	3.926	3.038	2.850	1.26	2.92	1.66
Sept.	14.125	5.141	3.236	2.827	1.25	2.94	1.69
Oct.	12.350	5.113	3.016	2.538	1.25	2.62	1.37
Nov.	11.000	4.940	2.845	2.286	1.30	2.36	1.06
Dec.	10.438	4.830	2.723	2.202	1.40	2.26	.86
AVERAGE	14.303	4.200	2.854	2.329	1.68	2.83	1.15
1923		41–43° Grav. Water White	36–38° Grav. Straw Dist.				
Jan.	11.650	4.515	3.352	2.298	1.51	2.51	1.00
			38–40° Grav. Straw Dist.				
Feb.	13.813	4.361	3.783	2.500	1.91	2.88	.97
Mar.	14.313	4.281	3.595	2.560	2.00	2.96	.96
Apr.	12.900	4.250	3.564	2.745	1.97	2.77	.80
May	11.438	4.064	3.331	2.545	1.65	2.49	.84
June	11.750	3.875	3.190	2.410	1.60	2.50	.90
July	9.400	3.875	2.940	2.202	1.60	2.09	.49
Aug.	8.438	3.875	2.908	2.304	1.60	1.96	.36
Sept.	6.938	3.875	2.908	2.101	1.51	1.70	.19
Oct.	6.300	3.901	3.177	1.964	1.30	1.59	.29
Nov.	6.125	4.051	3.125	1.780	1.07	1.54	.47
Dec.	6.600	4.538	3.125	1.905	1.00	1.66	.66
AVERAGE	9.915	4.131	3.250	2.280	1.56	2.21	.65

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† Wholesale value of typical refined products from one barrel of Mid-Continent crude oil.

Date	Oklahoma Refinery Tank Car Market* Cents per Gallon Gasoline	Kerosene	Gas Oil	Fuel Oil	Price in Dollars per Barrel Price at Well Crude Oil	Total Value of Refined Products†	Refining Margin
1924	58–60° Grav. New Navy 437 E.P.	41–43° Grav. Water White	38–40° Grav. Straw Dist.	24–26° Grav.	36° Grav.		
Jan.	10.875	5.469	4.156	2.452	1.38	2.51	1.13
Feb.	11.031	5.828	4.031	2.738	1.84	2.58	.74
Mar.	10.650	4.650	3.625	2.464	1.97	2.41	.44
Apr.	10.625	4.344	3.656	2.277	2.00	2.37	.37
May	9.750	4.375	3.531	1.979	2.00	2.19	.19
June	8.950	4.175	3.288	1.917	2.00	2.02	.02
July	8.375	4.125	3.531	1.920	1.85	1.95	.10
Aug.	7.625	4.281	3.328	1.889	1.50	1.82	.32
Sept.	7.300	4.725	3.688	2.261	1.38	1.85	.47
Oct.	6.875	4.813	3.813	2.261	1.25	1.81	.56
Nov.	7.625	4.516	3.641	2.462	1.25	1.93	.68
Dec.	8.300	4.438	3.788	2.827	1.25	2.10	.85
AVERAGE	8.979	4.636	3.656	2.288	1.64	2.12	.48
1925	58–60° Grav. U.S. Motor 437 E.P.			20–22° Grav.			
Jan.	8.375	4.438	4.031	3.117	1.34	2.23	.89
Feb.	12.375	4.781	3.953	3.155	1.87	2.92	1.05
Mar.	11.100	4.575	3.859	2.667	2.00	2.62	.62
Apr.	10.000	4.140	3.281	2.419	2.00	2.36	.36
May	11.188	4.250	3.125	2.157	2.00	2.52	.52
June	12.950	4.250	3.300	2.188	2.00	2.84	.84
July	12.190	4.015	3.360	2.135	2.03	2.69	.66
Aug.	10.376	4.225	3.613	2.457	2.00	2.44	.44
Sept.	9.250	4.937	3.794	2.471	1.79	2.29	.50
Oct.	8.720	4.984	3.906	2.486	1.79	2.21	.42
Nov.	9.650	4.987	4.031	2.767	1.79	2.41	.62
Dec.	9.938	5.125	4.062	2.917	1.79	2.49	.70
AVERAGE	10.568	4.559	3.735	2.580	1.87	2.51	.64
1926				18–22° Grav.			
Jan.	9.781	5.531	4.031	2.916	1.79	2.49	.70
Feb.	10.250	6.500	4.000	2.783	2.04	2.58	.54
Mar.	10.000	6.750	4.187	2.816	2.04	2.57	.53
Apr.	10.188	7.203	4.578	3.088	2.04	2.65	.61
May	11.625	10.000	4.641	3.057	2.18	3.02	.84
June	11.450	8.038	4.525	2.909	2.29	2.89	.60
July	11.156	6.531	4.641	2.850	2.29	2.78	.49
Aug.	11.000	8.625	5.350	3.100	2.29	2.89	.60
Sept.	10.625	8.969	5.719	3.207	2.29	2.86	.57
Oct.	9.843	7.141	5.734	3.057	2.29	2.64	.35
Nov.	9.050	6.600	5.375	2.947	2.11	2.45	.34
Dec.	9.250	6.312	5.375	2.902	1.90	2.48	.58
AVERAGE	10.351	7.350	4.846	2.969	2.13	2.69	.56

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† Wholesale value of typical refined products from one barrel of Mid-Continent crude oil.

Date	Oklahoma Refinery Tank Car Market* (Cents per Gallon) Gasoline	Kerosene	Gas Oil	Fuel Oil	Price in Dollars per Barrel: Price at Well Crude Oil	Total Value of Refined Products†	Refining Margin
1927	58–60° Grav. U.S. Motor 437 E.P.	41–43° Grav. Water White	38–40° Grav. Straw Dist.	14–16° Grav.	36° Grav.		
Jan.	8.950	5.988	5.213	2.769	1.90	2.40	.50
Feb.	8.156	6.078	4.766	2.769	1.84	2.24	.40
Mar.	6.687	5.188	4.031	2.671	1.37	1.90	.53
Apr.	6.312	4.453	3.250	2.261	1.28	1.72	.44
May	6.475	4.400	3.225	2.002	1.28	1.71	.43
June	6.593	4.234	3.219	2.023	1.28	1.73	.45
July	7.031	4.125	3.359	2.023	1.28	1.81	.53
Aug.	6.425	4.125	3.275	1.928	1.28	1.68	.40
Sept.	6.063	4.250	3.188	1.845	1.28	1.62	.34
Oct.	6.025	4.613	3.238	1.785	1.28	1.61	.33
Nov.	6.000	4.609	3.297	1.719	1.28	1.59	.31
Dec.	5.969	4.484	3.313	1.666	1.28	1.58	.30
AVERAGE	6.724	4.712	3.615	2.121	1.38	1.80	.42
1928			34–40° Grav.				
Jan.	5.713	4.275	3.25	1.667	1.28	1.54	.26
Feb.	5.966	4.188	3.00	1.793	1.28	1.60	.32
Mar.	6.181	4.348	3.00	1.845	1.28	1.65	.37
Apr.	6.335	4.913	3.00	1.875	1.28	1.75	.47
May	7.234	5.313	3.00	1.704	1.28	1.85	.57
June	7.669	4.938	2.875	1.577	1.28	1.90	.62
July	8.287	4.850	2.875	1.345	1.30	1.97	.67
Aug.	9.536	6.109	2.875	1.310	1.36	2.23	.87
Sept.	9.619	6.500	3.250	1.310	1.36	2.27	.91
Oct.	9.582	6.163	3.250	1.310	1.36	2.26	.90
Nov.	9.229	5.891	3.375	1.287	1.36	2.18	.82
Dec.	8.498	5.638	3.375	1.280	1.36	2.04	.68
AVERAGE	7.821	5.260	3.094	1.525	1.31	1.94	.63
1929			38–40° Grav.				
Jan.	7.880	5.407	3.688	1.257	1.32	1.91	.59
Feb.	6.656	5.344	4.094	1.213	1.20	1.69	.49
Mar.	6.816	6.031	4.172	1.220	1.20	1.74	.54
Apr.	7.281	6.638	3.700	1.214	1.20	1.83	.63
May	7.974	5.766	3.375	1.161	1.29	1.91	.62
June	9.088	5.906	3.359	1.131	1.45	2.11	.66
July	8.412	5.538	3.500	1.167	1.45	1.99	.54
Aug.	7.595	5.406	3.625	1.191	1.45	1.84	.39
Sept.	7.588	5.425	3.888	1.250	1.45	1.86	.41
Oct.	7.533	5.094	4.078	1.421	1.45	1.87	.42
Nov.	7.287	4.703	3.828	1.533	1.45	1.82	.37
Dec.	7.022	4.425	3.813	1.750	1.45	1.80	.35
AVERAGE	7.594	5.473	3.760	1.292	1.37	1.87	.50

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† Wholesale value of typical refined products from one barrel of Mid-Continent crude oil.

Date	Oklahoma Refinery Tank Car Market* Cents per Gallon Gasoline	Kerosene	Gas Oil	Fuel Oil	Price in Dollars per Barrel Price at Well Crude Oil	Total Value of Refined Products†	Refining Margin
1930							
	58–60° Grav. U.S. Motor 437 E.P.	41–43° Grav. Water White	38–40° Grav.	14–16° Grav.	36° Grav.		
Jan.	6.438	4.250	3.688	1.905	1.45	1.77	.32
Feb.	6.322	4.172	3.422	1.800	1.33	1.73	.40
Mar.	6.148	4.313	3.225	1.601	1.20	1.66	.46
Apr.	6.964	4.391	3.125	1.302	1.26	1.78	.52
May	6.977	4.219	3.125	1.280	1.29	1.77	.48
June	6.500	3.925	3.050	1.202	1.29	1.66	.37
July	6.188	3.531	3.000	1.042	1.29	1.57	.28
Aug.	6.143	3.422	3.000	1.012	1.29	1.55	.26
Sept.	5.925	3.313	3.000	1.012	1.29	1.51	.22
Oct.	5.575	3.313	3.063	1.012	1.24	1.44	.20
Nov.	4.875	3.297	3.063	1.012	.95	1.31	.36
Dec.	4.250	3.138	3.013	0.860	.95	1.16	.21
AVERAGE	6.025	3.773	3.148	1.253	1.23	1.58	.35
1931							
Jan.	4.150	3.172	2.969	0.982	.95	1.19	.24
Feb.	4.060	3.172	2.859	0.982	.95	1.17	.22
Mar.	3.600	2.925	2.600	0.923	.64	1.05	.41
Apr.	3.438	2.781	2.313	0.893	.59	1.00	.41
May	2.938	2.594	1.984	0.811	.59	.87	.28
June	2.475	2.263	1.575	0.655	.33	.73	.40
July	2.906	2.000	1.344	0.484	.26	.78	.52
Aug.	4.275	2.013	1.313	0.464	.46	1.06	.60
Sept.	3.438	2.063	1.500	0.536	.62	.90	.28
Oct.	3.781	2.063	1.719	0.551	.62	.98	.36
Nov.	4.650	2.238	1.925	0.566	.77	1.18	.41
Dec.	3.188	2.406	2.016	0.566	.77	.89	.12
AVERAGE	3.575	2.474	2.010	0.701	.63	.98	.35
1932							
	57–65 Octane U.S. Motor 437 E.P.						
Jan.	3.188	2.594	2.094	0.573	.77	.90	.13
Feb.	3.575	2.688	2.075	0.619	.77	.97	.20
Mar.	4.063	2.750	2.000	0.655	.77	1.09	.32
Apr.	5.250	3.844	2.156	0.781	.87	1.39	.52
May	5.175	4.175	2.213	0.893	.92	1.40	.48
June	5.438	3.328	2.125	0.893	.92	1.43	.51
July	5.063	2.859	2.125	0.893	.92	1.34	.42
Aug.	5.000	3.025	2.675	0.893	.92	1.35	.43
Sept.	4.594	3.109	2.938	0.908	.92	1.28	.36
Oct.	4.650	3.363	3.138	0.952	.92	1.31	.39
Nov.	4.594	3.609	3.406	1.012	.92	1.32	.40
Dec.	3.688	3.578	3.406	1.071	.80	1.14	.34
AVERAGE	4.523	3.243	2.529	0.845	.87	1.24	.37

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† Wholesale value of typical refined products from one barrel of Mid-Continent crude oil.

Date	Oklahoma Refinery Tank Car Market* Cents per Gallon Gasoline	Kerosene	Gas Oil	Fuel Oil	Price in Dollars per Barrel Price at Well Crude Oil	Total Value of Refined Products†	Refining Margin
1933							
	57–65 Octane U.S. Motor 437 E.P.	41–43° Grav. Water White	38–40° Grav.	14–16° Grav.	36° Grav.		
Jan.	2.800	3.225	3.063	1.000	.58	.92	.34
Feb.	2.563	2.641	2.469	0.923	.44	.82	.38
Mar.	2.563	2.516	2.000	0.870	.44	.80	.36
Apr.	2.344	2.547	1.891	0.789	.44	.74	.30
	60–64 Octane U.S. Motor 437 E.P.						
May	2.600	2.813	1.913	0.774	.28	.80	.52
June	3.688	2.703	1.953	0.796	.34	1.03	.69
July	4.800	2.713	2.125	0.833	.52	1.27	.75
Aug.	4.063	2.484	2.188	0.863	.56	1.12	.56
Sept.	5.156	3.188	2.781	1.131	.85	1.42	.57
Oct.	5.125	3.413	3.013	1.274	1.00	1.44	.44
Nov.	5.000	3.391	3.094	1.376	1.00	1.43	.43
Dec.	4.969	3.375	3.250	1.429	1.00	1.44	.44
AVERAGE	3.806	2.917	2.478	1.003	.62	1.10	.48
1934							
Jan.	4.813	3.350	3.150	1.429	1.00	1.41	.41
Feb.	4.750	3.313	2.922	1.429	1.00	1.39	.39
Mar.	4.375	3.406	2.688	1.481	1.00	1.31	.31
Apr.	4.500	3.713	2.763	1.548	1.00	1.35	.35
May	4.750	3.578	2.813	1.555	1.00	1.40	.40
June	4.625	3.313	2.656	1.577	1.00	1.37	.37
July	4.525	3.213	2.488	1.577	1.00	1.34	.34
	63–70 Octane U.S. Motor 437 E.P.						
Aug.	4.718	3.172	2.500	1.577	1.00	1.38	.38
Sept.	4.625	3.172	2.656	1.577	1.00	1.36	.36
Oct.	4.275	3.150	2.788	1.577	1.00	1.30	.30
Nov.	4.656	3.375	3.031	1.577	1.00	1.39	.39
Dec.	4.550	3.400	3.200	1.629	1.00	1.38	.38
AVERAGE	4.597	3.346	2.804	1.545	1.00	1.37	.37
1935			Av. of No. 1 White 38–40 & No. 1 Straw				
Jan.	4.525	3.563	3.250	1.659	1.00	1.40	.40
Feb.	4.406	3.578	3.125	1.607	1.00	1.37	.37
Mar.	4.625	3.531	3.125	1.607	1.00	1.41	.41
Apr.	5.100	3.600	3.125	1.631	1.00	1.53	.53
May	5.344	4.109	3.250	1.637	1.00	1.59	.59
June	5.625	4.000	3.250	1.637	1.00	1.64	.64
July	5.625	3.388	3.000	1.613	1.00	1.61	.61
Aug.	5.625	3.453	3.000	1.577	1.00	1.61	.61
Sept.	5.625	3.413	3.125	1.554	1.00	1.61	.61

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† Wholesale value of typical refined products from one barrel of Mid-Continent crude oil.

Date	Oklahoma Refinery Tank Car Market* Cents per Gallon Gasoline	Kerosene	Gas Oil	Fuel Oil	Price in Dollars per Barrel Price at Well Crude Oil	Total Value of Refined Products†	Refining Margin
	63–70 Octane U.S. Motor 437 E.P.	41–43° Grav. Water White	Ave. of No. 1 White & No. 1 Straw	38–40	14–16° Grav.	36° Grav.	
Oct.	5.625	3.438	3.125	1.458	1.00	1.60	.60
Nov.	5.625	3.406	3.125	1.488	1.00	1.60	.60
Dec.	5.625	3.375	3.125	1.488	1.00	1.60	.60
AVERAGE	5.281	3.571	3.135	1.580	1.00	1.55	.55
1936			No. 1 Straw				
Jan.	6.000	3.531	3.313	1.503	1.07	1.70	.63
Feb.	6.125	3.688	3.438	1.548	1.10	1.74	.64
Mar.	5.975	4.175	3.488	1.577	1.10	1.73	.63
	68–70 Octane U.S. Motor 437 E.P.						
Apr. 15th	6.000	4.391	3.594	1.577	1.10	1.74	.64
May	6.000	4.203	3.547	1.547	1.10	1.73	.63
June	6.000	3.913	3.313	1.518	1.10	1.71	.61
July	6.000	3.563	3.109	1.518	1.10	1.70	.60
Aug.	5.900	3.213	2.925	1.518	1.10	1.66	.56
Sept.	5.531	3.125	2.984	1.518	1.10	1.58	.48
Oct.	5.594	3.219	3.109	1.518	1.10	1.60	.50
Nov.	5.700	3.488	3.325	1.566	1.10	1.65	.55
Dec.	5.750	3.781	3.531	1.637	1.10	1.68	.58
AVERAGE	5.863	3.691	3.306	1.545	1.10	1.69	.59
1937							
Jan.	5.687	3.891	3.656	1.637	1.12	1.69	.57
Feb.	5.750	4.219	3.968	1.887	1.22	1.75	.53
Mar.	5.725	4.250	3.925	1.964	1.22	1.76	.54
Apr.	6.031	4.266	3.813	1.964	1.22	1.82	.60
May	6.125	4.297	3.797	1.964	1.22	1.84	.62
June	6.100	4.263	3.750	1.964	1.22	1.83	.61
July	6.000	4.156	3.750	1.964	1.22	1.80	.58
Aug.	6.000	4.125	3.763	1.964	1.22	1.80	.58
	70–72 Octane U.S. Motor 437 E.P.						
Sept. 20th	6.000	4.125	3.813	1.964	1.22	1.81	.59
Oct.	5.900	4.125	3.875	1.964	1.22	1.79	.57
Nov.	5.325	4.125	3.888	1.964	1.22	1.66	.44
Dec.	5.031	4.156	4.000	1.964	1.22	1.61	.39
AVERAGE	5.806	4.166	3.833	1.931	1.22	1.76	.54
1938							
Jan.	4.875	4.313	4.125	1.964	1.22	1.58	.36
Feb.	4.875	4.281	4.063	1.964	1.22	1.58	.36
Mar.	5.063	4.219	3.875	1.935	1.22	1.61	.39
Apr.	5.250	4.188	3.813	1.920	1.22	1.64	.42

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† Wholesale value of typical refined products from one barrel of Mid-Continent crude oil.

Date	Oklahoma Refinery Tank Car Market* Cents per Gallon Gasoline	Kerosene	Gas Oil	Fuel Oil	Price in Dollars per Barrel Price at Well Crude Oil	Total Value of Refined Products†	Refining Margin
	70–72 Octane U.S. Motor 437 E.P.	41–43° Grav. Water White	No. 1 Prime White	14–16° Grav.	36° Grav.		
May	5.075	4.188	3.813	1.833	1.22	1.59	.37
June	5.313	4.234	3.813	1.786	1.22	1.64	.42
July	5.500	4.313	3.875	1.786	1.22	1.69	.47
Aug.	5.450	4.200	3.875	1.714	1.22	1.66	.44
Sept.	5.063	4.094	3.844	1.666	1.22	1.57	.35
			No. 1 Straw				
Oct.	4.625	4.038	3.750	1.666	1.08	1.47	.39
Nov.	4.594	4.063	3.750	1.666	1.02	1.47	.45
Dec.	4.313	4.094	3.766	1.666	1.02	1.41	.39
AVERAGE	4.997	4.185	3.864	1.799	1.18	1.57	.39

* Prices of gasoline are the averages of the low quotations. Prices of all other products are the averages of the high and low quotations.
† Wholesale value of typical refined products from one barrel of Mid-Continent crude oil.

PRODUCT YIELDS

(Gallons per Barrel)

Year	Gasoline	Kerosene	Gas Oil*	Fuel Oil and Still Gas	Specialties†	Misc. and Loss	Total
1920	12.81	5.75	5.50	15.00	.08	2.86	42.00
1921	13.90	4.79	5.50	15.17	.08	2.56	42.00
1922	14.83	4.66	5.50	15.08	.04	1.89	42.00
1923	15.42	4.20	5.00	15.16	.08	2.14	42.00
1924	15.79	3.91	5.00	15.03	.13	2.14	42.00
1925	17.05	3.40	4.50	14.91	.21	1.93	42.00
1926	17.60	3.36	4.00	14.40	.29	2.35	42.00
1927	18.06	3.23	3.77	14.00	.42	2.52	42.00
1928	18.22	3.19	3.40	14.74	.50	1.95	42.00
1929	18.04	2.90	3.58	14.74	.54	2.20	42.00
1930	19.82	2.59	3.32	12.93	.80	2.54	42.00
1931	20.52	2.39	4.21	11.93	.91	2.04	42.00
1932	21.07	2.56	3.79	11.64	.97	1.97	42.00
1933	20.85	2.63	3.70	12.06	.87	1.89	42.00
1934	21.01	2.63	3.81	11.67	.97	1.91	42.00
1935	21.10	2.73	4.12	11.86	.85	1.34	42.00
1936	21.16	2.39	4.50	11.96	.94	1.05	42.00
1937	21.54	2.43	4.54	11.13	.96	1.40	42.00

* Lubricating oil and wax are included with gas oil.
† Specialties include asphalt, road oil, and coke.

DISCUSSION

C. W. TOMLINSON, Ardmore, Oklahoma (discussion received, April 7, 1939): Mr. Swensrud has presented an able demonstration of the lag of crude price adjustments behind changes in prices of refined products. Supporting

his statement with a useful compilation of price data for the years 1920 to 1938 inclusive, he has brought out clearly the greater sensitiveness of refined prices, and the fact that they change more readily and frequently than crude oil prices.

The most important conclusions which Mr. Swensrud has drawn from that analysis are that the lag of downward movements in crude oil prices operates to the disadvantage of the refining industry; and that this lag has been more pronounced since State proration became a general practice about 1930. It is implied that it would be desirable to have crude prices depend more directly upon product prices.

Mr. Swensrud's own statistics contain within themselves a complete defense for the producer against the implied charge that he has, in general, benefited at the expense of the refiner, under the proration practices of recent years. Witness the following figures, which are simple averages of the annual figures presented by Mr. Swensrud.

AVERAGE PRICE FOR CRUDE OIL

1920 to 1928 inclusive	$1.85 per barrel
1930 to 1938	.98 per barrel
Decrease	.87 (47 per cent)

AGGREGATE VALUE OF REFINED PRODUCTS PRODUCED FROM ONE BARREL OF CRUDE OIL

Average 1920 to 1928	$2.59 per barrel
Average 1930 to 1938	1.43 per barrel
Decrease	1.16 (45 per cent)

REFINER'S MARGIN ABOVE THE PRICE OF CRUDE OIL

Average 1920 to 1928	$ .74 (40 per cent of the price of crude)
Average 1930 to 1938	.45 (46 per cent of the price of crude)
Decrease	.29 (40 per cent)

Between the two 9-year periods covered by Mr. Swensrud's figures (omitting 1929 to make the two periods equal in length), the refiner suffered a loss of 29 cents in his average margin between crude and refined prices; but the producer in the same time suffered a loss of 87 cents per barrel in the average price of crude. Because of the producer's greater loss, the refiner's *percentage* margin actually increased from 40 per cent to 46 per cent of the price of crude oil. The producer, not the refiner, would have benefited by maintenance in the last decade of a ratio between crude and product prices fixed in the previous ten years.

It would be unworthy of the producer to cast any shadow on the extraordinary service the refining industry has rendered to the nation in so greatly improving its methods as to have made possible a decrease of 40 per cent in a single decade, in the cost of its services to the public. Few industries have ever approached that achievement. But the record shows that the oil producer instead of playing second fiddle to the refiner in this respect, has outclassed him by reducing the price of his product 47 per cent in the same decade. Instead of occupying a protected position as implied by Mr. Swensrud, the producer has suffered more severe curtailment of income than the refiner. He may have taken his medicine more tardily, but he has taken more of it.

And out of their reduced income both the producer and the refiner pay greatly increased taxes. By increasing its efficiency, the oil industry has completely absorbed the multiple burdens of taxation which have been heaped upon it during these two decades,—keeping retail prices lower than before.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE, 1939), PP. 789-794, 2 FIGS.

WILDCAT DRILLING IN 1938[1]

FREDERIC H. LAHEE[2]
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ABSTRACT

In this paper statistics on wildcat drilling have been reviewed for the year 1938. Figures are given separately for the Gulf Coastal Plain states and for the whole United States, exclusive of a few eastern states from which data were not obtained. During 1938 the campaign of wildcat drilling continued with increased fervor. More holes and more footage were drilled, and more new pools were discovered. The question is raised as to what may be the outcome of this aggressive drilling for new reserves if it persists.

This paper reviews data on wildcat drilling for the fourth consecutive year.[3] In the first two articles (referring to the years 1935, 1936, and 1937), only the Gulf Coastal Plain states were covered. The third article ("Further Notes" . . . etc.), included most of the states in which drilling has been undertaken in search of oil, west of Ohio, Kentucky, and the Atlantic seaboard states. For purposes of comparison with these earlier articles, the present paper treats the subject, first, for the Gulf Coastal Plain states and then for the whole country, excluding Ohio and more eastern states from which information has not been received.

In compiling the data, we have tried as far as possible to adhere to the definition of a *wildcat* as a hole drilled completely outside the known boundaries of pools already developed, and far enough from producing areas to be essentially a test of new possibilities. Such a hole would usually be at least two or three miles from production; yet in some cases, notably in association with salt domes, a wildcat might be much closer to the edge of the known pool. The term would include all true discoveries of new pools, but not discoveries of new sands *within* old pools of which the structure and areal extent are known. However, the term *would* include holes finding new pay sands off the flanks of known producing structures and outside the limits of the known producing area, and also holes finding new pay sands on struc-

[1] The writer wishes to express his sincere gratitude to these gentlemen for their willing assistance in compiling and sending to him the abundant data used in preparing this paper: A. P. Allison, A. H. Bell, K. E. Born, A. E. Brainerd, G. E. Burton, G. V. Cohee, R. J. Cullen, G. F. Fix, G. C. Gester, E. W. Hard, C. T. Jones, E. A. Koester, C. S. Lavington, A. M. Lloyd, J. J. Maucini, G. B. Moody, D. J. Munroe, C. R. Nichols, R. E. Rettger, C. H. Row, T. C. Stauffer, E. B. Wilson.
Manuscript received, April 12, 1939.

[2] Chief geologist, Sun Oil Company.

[3] See "Wildcat Drilling in 1935 and 1936," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 21, No. 8 (August, 1937), pp. 1079–82; "Wildcat Drilling in 1937," *ibid.*, Vol. 22, No. 6 (June, 1938), pp. 645–48; "Further Data on Wildcat Drilling in 1937," *ibid.*, Vol. 22, No. 9 (September, 1938), pp. 1231–35; "Corrections in Article on Wildcat Drilling . . . ," *ibid.*, Vol. 22, No. 9 (September, 1938), p. 1236.

NEW MEXICO
5 (16,507)
7 (33,220)
OKLAHOMA
ARKANSAS
4 (27,319)
29 (93,198)
MISSISSIPPI
ALABAMA
GEORGIA
TOTAL
200 (984,262)
1271 (4,667,402)
ONE PRODUCER FOOT
FOR EVERY
4.74 FEET DRY
4 (14,372)
33 (113,317)
53 (182,649)
228 (551,153)
12 (51,758)
104 (394,740)
12 (73,089)
64 (255,880)
0 (0)
13 (57,756)
0 (0)
4 (16,360)
0 (0)
1 (4,375)
TEXAS
LOUISIANA
0 (0)
18 (129)
FLORIDA
18 (58,677)
106 (410,066)
20 (136,839)
111 (690,402)
19 (187,820)
64 (469,361)
9 (12,534)
172 (346,088)
44 (212,698)
344 (1,225,357)
WILDCATS, 1938

FIG. 1

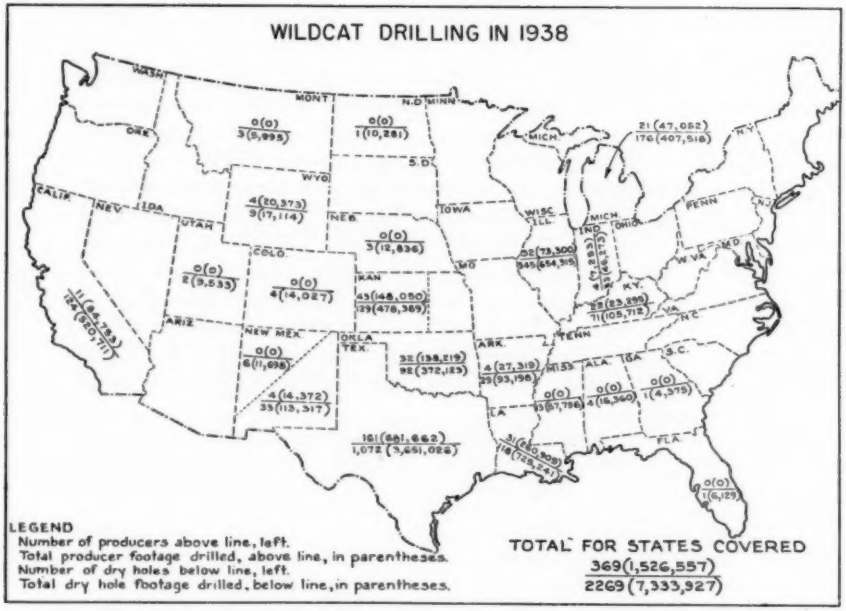
WILDCAT DRILLING IN 1938
WASH.
MONT
N.D.
MINN.
ORE.
0 (0)
3 (5,995)
0 (0)
1 (10,281)
MICH.
21 (47,052)
176 (407,518)
N.Y.
S.D.
WYO.
CALIF.
NEV.
IDA.
UTAH
4 (20,373)
9 (17,114)
NEB.
IOWA
WISC.
ILL.
MICH.
IND.
OHIO
PENN.
N.J.
0 (0)
3 (12,836)
32 (73,300)
345 (634,315)
COLO.
0 (0)
2 (9,533)
0 (0)
4 (14,027)
KAN.
MO.
W. VA.
MD.
43 (48,050)
129 (478,369)
KY.
25 (23,299)
71 (105,712)
VA.
N.C.
ARIZ.
11 (44,253)
124 (560,717)
NEW MEX.
OKLA.
TEX.
ARK.
TENN.
0 (0)
6 (11,698)
32 (138,219)
92 (372,183)
4 (27,319)
29 (93,198)
MISS.
ALA.
GA.
S.C.
4 (14,372)
35 (113,317)
0 (0)
35 (57,756)
0 (0)
4 (16,360)
0 (0)
1 (4,375)
LA.
161 (661,662)
1,072 (5,651,028)
31 (250,909)
116 (1,158,241)
FLA.
0 (0)
1 (6,129)
LEGEND
Number of producers above line, left.
Total producer footage drilled, above line, in parentheses.
Number of dry holes below line, left.
Total dry hole footage drilled, below line, in parentheses.
TOTAL FOR STATES COVERED
369 (1,526,557)
2269 (7,333,927)

FIG. 2

tures where very few producers had been completed. In spite of every effort to standardize this conception of a wildcat hole, different geologists have somewhat different ideas on the subject, so that final statistics can not be mathematically exact; but we feel that the results are correct within a very small and inconsequential limit of error.

On the map in Figure 1, numbers in parentheses indicate total footage drilled; figures preceding parentheses indicate the number of holes drilled; figures above the cross line are for producing wells, both oil and gas; and figures below the cross line are for dry holes. In this area (Fig. 1), during 1938, a total of 5,651,664 feet was drilled in 1,471 holes, divided as follows.

200 producers..... 984,262 feet
1,271 dry holes.....4,667,402 feet

This means that 13.6 per cent of the holes drilled, and 17.4 per cent of the footage drilled was successful.

In our earlier reports on wildcat drilling in states of the Coastal Plain area,[4] data were not available on North-Central Texas and the Panhandle of Texas, and therefore these districts were omitted in the calculations. In order to permit fair comparison of this year's figures with those of 1935, 1936, and 1937, we are similarly omitting these two districts of Texas from the totals mentioned in Table I.

TABLE I

COMPARATIVE STATISTICS FOR GULF COASTAL PLAIN STATES, OMITTING NORTH-CENTRAL TEXAS AND PANHANDLE OF TEXAS

	Producers Drilled				*Dry Holes Drilled*				*Total Number Wild-Cats Drilled*	*Average Depth of Hole (Feet)*	*Number of Dry-Hole Feet Drilled for Each Producer Foot*
	Holes		*Footage*		*Holes*		*Footage*				
	Number	*Per Cent*	*Feet*	*Per Cent*	*Number*	*Per Cent*	*Feet*	*Per Cent*			
1935	78	7.32	354,834	9.7	987	92.68	3,415,296	90.3	1,065	3,540	9.63
1936	116	10.67	527,286	12.8	971	89.33	3,585,676	87.2	1,087	3,783	6.80
1937	138	12.1	765,690	15.7	1,002	87.9	4,096,990	84.3	1,140	4,090	5.35
1938	142	12.0	785,106	16.1	1,036	88.0	4,083,029	83.9	1,178	4,132	5.21

This table shows a steadily increasing percentage of producers and of footage drilled in producers, and also a decreasing footage drilled in dry holes for every producer foot. It also reveals a steady increase both in the number of wildcat wells drilled each year and in the average depth per hole.

To provide a basis for comparison for future years, we submit in Table II figures for the entire area shown in Figure 1 (i.e., including all of Texas).

Figure 2 exhibits the data on wildcat drilling for 1938 in most of the states of the United States where this kind of exploration is active. These data are listed in Table III.

[4] First two articles mentioned in footnote 3.

TABLE II

STATISTICS FOR ALL GULF COASTAL PLAIN STATES SHOWN IN FIGURE 1, FOR 1938 ONLY

Producers drilled in 1938			
Number of holes:	200	Per cent:	13.6
Total footage of holes:	984,262	Per cent:	17.4
Dry holes drilled in 1938			
Number of holes:	1,271	Per cent:	86.4
Total footage of holes:	4,667,402	Per cent:	82.6
Total number of wildcats drilled in 1938:			1,471
Average depth of hole:	3,842 feet		
Number of dry-hole feet drilled for each producer foot:			4.74

TABLE III

NUMBER OF OIL WELLS, GAS WELLS, AND DRY HOLES DRILLED AS WILDCATS IN 1938

States	*Oil*		*Gas*		*Dry*		*Total Number of Holes*	*Total Footage Drilled*
	Number of Holes	*Footage Drilled*	*Number of Holes*	*Footage Drilled*	*Number of Holes*	*Footage Drilled*		
Alabama	—	—	—	—	4	16,360	4	16,360
So. Arkansas	4	27,319	—	—	29	93,198	33	120,517
California	10	77,045	1	7,708	124	520,711	135	605,464
Colorado	—	—	—	—	4	14,027	4	14,027
Florida	—	—	—	—	1	6,129	1	6,129
Georgia	—	—	—	—	1	4,375	1	4,375
Illinois	27	70,156	5	3,144	345	654,315	377	727,615
Indiana	2	5,629	2	1,624	33	46,273	37	53,526
W. Kansas	41	139,995	2	8,055	129	478,389	172	626,439
Kentucky	16	16,624	6	6,671	71	105,712	93	129,007
Louisiana	18	144,894	13	116,015	118	725,241	149	986,150
Michigan	21	47,052	—	—	176	407,518	197	454,570
Mississippi	—	—	—	—	13	57,756	13	57,756
Montana	—	—	—	—	3	5,995	3	5,995
Nebraska	—	—	—	—	3	12,836	3	12,836
NW. New Mexico	—	—	—	—	6	11,698	6	11,698
SE. New Mexico	3	10,386	1	3,986	33	113,317	37	127,689
No. Dakota	—	—	—	—	1	10,281	1	10,281
Oklahoma	27	125,891	5	12,328	92	372,123	124	510,342
Texas	123	489,095	38	192,567	1,072	3,651,026	1,233	4,332,688
Utah	—	—	—	—	2	9,533	2	9,533
Wyoming	2	9,101	2	11,272	9	17,114	13	37,487
Total	294	1,163,187	75	363,370	2,269	7,333,927	2,638	8,860,484
Per cent of total	11.14	13.13	2.84	4.10	86.02	82.77	100.00	100.00

Out of the total 2,638 wildcat holes drilled, 369, or 13.98 per cent, were successful; and of the 8,860,484 feet drilled, 1,526,557 feet, or 17.22 per cent, were drilled in the producing wells. For every producer foot, 4.8 feet of dry hole were drilled. The average depth of all the wildcats, producing and dry, was 3,358.7 feet. Except for the average depth of hole, these figures are very similar to those given for the Gulf Coastal Plain states.

Selection of the location for a wildcat well may be based on surface

geology, subsurface geology, trend from known structural or stratigraphic conditions, or shallow exploratory drilling; or it may be based on geophysical features, mapped by seismograph, torsion balance, gravity meter, magnetometer, *et cetera;* or it may be based on some non-technical suggestion or requirement, such as "creekology," "hunch," promotion, lease obligation, reported showings of oil or gas in holes previously drilled, *et cetera*. In many instances the reason for the location can not be ascertained.

TABLE IV

BASIS FOR LOCATING WILDCATS DRILLED IN 1938

State	*Geology*		*Geophysics*		*Geology and Geophysics*		*Sundry Non-Technical*		*Unknown*		*Totals*	
	Dry	*Prod.*	*Dry*	*Prod.*	*Dry*	*Prod.*	*Dry*	*Prod.*	*Dry*	*Prod.*	*Dry*	*Prod.*
Alabama	2	—	—	—	—	—	2	—	—	—	4	0
So. Arkansas	12	1	—	—	5	3	6	—	6	—	29	4
California	44	5	21	3	12	2	13	1	34	—	124	11
Colorado	2	—	1	—	—	—	1	—	—	—	4	0
Florida	—	—	—	—	1	—	—	—	—	—	1	0
Georgia	—	—	1	—	—	—	—	—	—	—	1	0
Illinois	21	9	10	4	16	9	97	3	201	7	345	32
Indiana	—	—	—	—	—	—	—	—	33	4	33	4
W. Kansas	34	17	6	6	1	2	88	18	—	—	129	43
Kentucky	42	13	2	—	1	1	1	1	25	7	71	22
Louisiana	31	13	44	17	1	—	25	1	17	—	118	31
Michigan	118	15	3	1	—	—	55	5	—	—	176	21
Mississippi	4	—	2	—	—	—	7	—	—	—	13	0
Montana	3	—	—	—	—	—	—	—	—	—	3	0
Nebraska	—	—	1	—	—	—	2	—	—	—	3	0
NW. New Mexico	1	—	—	—	—	—	5	—	—	—	6	0
SE. New Mexico	12	—	4	1	—	—	17	2	—	1	33	4
No. Dakota	—	—	—	—	1	—	—	—	—	—	1	0
Oklahoma	30	13	23	12	—	—	33	7	6	—	92	32
Texas	677	104	134	34	30	12	181	6	50	5	1,072	161
Utah	2	—	—	—	—	—	—	—	—	—	2	0
Wyoming	6	2	—	—	1	2	2	—	—	—	9	4
Totals	1,041	192	252	78	69	31	535	44	372	24	2,269	369

In Table IV we have listed the reasons for drilling the 1938 wildcats, using the best information that we could secure from men familiar with such statistics, each in his own state or district. According to these figures, 301 wildcats drilled on technical advice, were successful (oil or gas), and 1,362 were dry; 44 holes drilled for various non-technical reasons were producers, and 535 were dry. In other words, 18.09 per cent of the holes drilled on technical advice were successful, whereas only 8.22 per cent of those drilled without technical advice found oil or gas. Locations based on technical recommendations were more than twice as successful as those drilled without such advice.

In the Gulf Coastal Plain states, included in Figure 1, 5 per cent of the wildcats, located *without* technical advice, were producers, whereas 16.08 per cent of the holes located *on* technical evidence were producers. The fact that only from 16 to 18 per cent of the wildcats drilled on technical advice found oil or gas is significant of the uncertainties of geology and of the consequent difficulties of interpretation of available technical data. The impressive thing is that the holes located on technical advice were from 2.2 to 3.2 times as successful as those drilled without such advice.[5]

As a result of all this wildcat drilling, many new pools were discovered. Due to the fact that a new oil or gas well may eventually turn out to be an extension of an old pool, early classification of such new producers is not always correct, and records may vary. But whatever classification is used, there were more pools found in 1938 than in 1937, and in 1937 nearly half again as many pools were discovered as in 1936.[6]

Wildcat drilling is largely the industry's response to recommendations made by geologists and geophysicists. We geologists are therefore particularly concerned with it, and rightly we view with pride the record of the last four years,—(1) increasing proportion of producers to dry holes in total number of wildcats drilled; (2) reduction of number of feet drilled in dry holes for every foot drilled in producers, in spite of increasing average depth per hole; (3) increasing success in the discovery of new pools; and (4) maintenance of approximately the 3 to 1 factor of success in technical locations as contrasted with non-technical locations. These are fine accomplishments, but what do they mean and whither do they lead in the larger picture of oil exploration and development?

The three main incentives for wildcatting are the lure of pioneering, the urge to augment reserves, and the pressure caused by approaching termination of lease-hold interests. To what extent has each of these incentives controlled the campaign of wildcatting? To what extent will each, individually and relatively, control future wildcatting? What may be the effects of continued discovery of many new pools through a period of several years? These are important questions which may well be considered in relation to certain major problems of oil-field development.

[5] After completion of this report, the following data were received from Tennessee.
80 holes drilled, 16 being oil wells and 5 being gas wells.
Total footage drilled, 63,385 feet.
Holes drilled on technical advice: 14 oil, 2 gas, 14 dry.
Holes drilled without technical advice: 2 oil, 3 gas, 45 dry.

[6] See *The Oil Weekly*, Vol. 92, Jan. 30, 1939, pp. 97–133.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE 1939), PP. 795-796

WILDCAT ACTIVITY IN KANSAS, 1938[1]

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Wichita, Kansas

The search for new petroleum reserves in the United States continues on a wide front. Due to economic conditions, wildcatting in Kansas in recent years has tended to diminish. Loss of markets to other states has reduced budgets of Kansas companies to such a point as to curtail exploration in rank wildcat territory. Other elements entering into the Kansas wildcat picture in 1938 were as follows.

(1) Approaching expiration of acreage, causing many companies to farm out leases of somewhat questionable value. Forty-nine wildcat "farm-outs" were drilled in 1938.
(2) Refusal of pipe-line companies to make connections with many new discoveries.
(3) Unwillingness of major companies to support wildcat wells unless located near short-term leases.

Forty-one oil fields and two gas fields were the fruits of one hundred seventy-two wildcat tests located in western Kansas, namely that part of the state west of the Sixth Principal Meridian. Only three of these may be considered as definitely opening up productive areas of considerable size. The foregoing classification follows the recommendations of the nomenclature committee of the Kansas Geological Society, and includes many areas which most likely will later be shown to be parts of a previously discovered field. In other words, many of these so-called discoveries are actually extensions.

The total footage of the oil and gas discoveries was 148,050 feet, or an average depth of 3,443 feet. These may be divided as to producing zones as follows.

	Number of Wells
Arbuckle limestone	26
Lansing-Kansas City	10
"Mississippi lime"	4
Viola lime	1
Simpson sand	1
Stranger sand	1

One hundred twenty-nine wildcat dry holes had a total footage of 478,389 feet for an average depth of 3,708 feet. The stratigraphic horizons reached by these wells are as follows.

[1] Manuscript received, March 6, 1939.

[2] Darby Petroleum Corporation, 802 Ellis-Singleton Building.

	Number of Wells
Pre-Cambrian	1
Arbuckle	112
Simpson	1
Hunton (Sil.-Dev.)	1
Mississippian	5
Pennsylvanian	5
Permian	2
Cretaceous	2

The foregoing list includes Watchorn Oil Company's Watkins No. 1 in Sec. 23, T. 32 S., R. 21 W., Clark County, completed in the Arbuckle limestone at 7,136 feet, the deepest well ever drilled in Kansas.

The following table classifies all wildcat wells in western Kansas according to the method of location.

		Producing	*Dry*	*Total*
Non-geological				
Chance		7	74	81
Expiring acreage		11	14	25
Geological				
Surface		3	4	7
Subsurface		8	11	19
Surface and subsurface		0	3	3
Core drill		6	14	20
Seismograph		6	6	12
Core drill and subsurface		0	2	2
Core drill and seismograph		0	1	1
Seismograph and subsurface		2	0	2
	Success Percentage			
Non-geological	17.9	18	88	106
Geological	37.8	25	41	66
		43	129	172

Twelve of the eighteen non-geological discoveries should be considered as extensions of old fields, but at present they are considered as separate pools by the Kansas nomenclature committee. Therefore, the success percentage of non-geological wildcats is actually about 6 per cent.

For the first time geophysical methods are responsible for a considerable proportion of the new fields discovered in any one year in Kansas. This suggests an improvement in geophysical technique, and a better understanding of Kansas subsurface problems by geologists and geophysicists. The relatively low proportion of discoveries attributed to surface methods indicates that most of the surface structural features in the state have been explored.

The writer acknowledges the coöperation of the many geologists who have worked with him in assembling the information contained in this study.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE, 1939), PP. 797-806, 3 FIGS.

DEVELOPMENTS IN KANSAS, 1938[1]

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Wichita, Kansas

ABSTRACT

Drilling activity in Kansas dropped about 41 per cent below the previous year. The dry-hole percentage rose about 1 per cent and the average initial potential of oil wells fell nearly 100 barrels. The use of acid in the southwest Kansas gas area increased the initial potentials in this area about 25 per cent.

The general oil-producing area of western Kansas was extended about 15 miles northwest by the discovery of the Morel pool in Sec. 15, T. 9 S., R. 21 W., Graham County. Activity continued in the Zenith pool where 90 wells were drilled during the year. Discovery of Arbuckle dolomite production in the old Hittle pool was an important development in Cowley County for the year.

Early in the year there was considerable leasing activity in Graham, Sheridan, and Decatur counties which was caused by the discovery of the Morel pool. A very active leasing campaign was in progress at the close of the year in the Forest City basin in northeastern Kansas and adjoining areas.

INTRODUCTION

It is the purpose of this paper to present a brief summary of oil and gas developments in Kansas during 1938, touching briefly on the leasing activity and geologic work done.

There was a general curtailment of all types of development and exploration throughout the year because of the slackened demand for Kansas oil.

DRILLING ACTIVITY

The drilling activity in Kansas for the last 2 years is summarized in Table I.

TABLE I

SUMMARY OF 1938 DRILLING IN KANSAS

	1937	*Per Cent*	*1938*	*Per Cent*
Oil wells	1,917	71.4	1,117	73.9
Gas wells	127	4.7	62	
Water disposal wells	—	—	24	1.5
Dry holes	638	23.9	391	24.6
Total	2,682		1,594	

Table I shows a drop of nearly 1,100 wells drilled (41 per cent) below the previous year.

PRODUCTION

The drop in activity was caused by a lower demand for Kansas oil in 1938 than in 1937. This lower demand for oil is shown by Table II

[1] Read before the Association at Oklahoma City, March 23, 1939. Manuscript received, April 21, 1939.

[2] District geologist, Phillips Petroleum Company.

which gives the average daily allowable and daily runs for the 2 years.

TABLE II

AVERAGE DAILY ALLOWABLE AND PIPE-LINE RUNS

	1937		1938	
	Daily State Allocation	*Daily Average Pipe-Line Runs*	*Daily State Allocation*	*Daily Average Pipe-Line Runs*
Jan.	175,851	166,118	186,472	177,688
Feb.	187,998	186,574	176,400	166,683
March	186,968	190,035	169,528	166,843
April	190,200	194,581	173,000	166,127
May	187,100	203,753	160,000	150,590
June	190,700	198,792	160,000	154,925
July	195,600	201,003	165,000	157,238
August	200,500	193,785	165,500	161,921
Sept.	196,250	196,090	165,500	156,928
October	193,800	188,499	163,400	150,007
Nov.	180,215	179,176	163,400	151,497
Dec.	176,700	174,737	163,400	153,953

During part of 1937 the pipe-line runs exceeded the state allocation but in 1938 the pipe-line runs were consistently below the state allocation. During this period of 2 years the state potential rose from 1,634,307 barrels at the beginning of 1937, to 3,681,016 barrels at the close of 1938.

LEASING ACTIVITY

Leasing activity declined in proportion to other functions of the petroleum industry. The discovery of the Morel pool early in the year in Graham County stimulated leasing in Graham, Sheridan, and Decatur counties for about 2 months. During most of the rest of the year leasing was spotted and quiet. Several rather large blocks were taken early in the year on the west flank of the Nemaha granite ridge in Pottawatomie, Marshall, Riley, and Wabaunsee counties. Many leases were dropped in the Clark County area and in central-western Kansas south of the Central Kansas uplift.

In the last 2 months of the year a very active leasing campaign was in progress in northeastern Kansas and adjoining parts of Missouri and Nebraska in the Forest City basin. This general lease play, covering most of northern Missouri, southwestern Iowa, southeastern Nebraska, and northeastern Kansas, is the industry's largest lease play to date which has had no basis of actual production in the area.

GEOLOGIC WORK

The methods of geological exploration in Kansas remain about the same for the year. From 7 to 16 core drills were reported each

week during the year making a total of 562 core-drill weeks or an average of 10.8. The number of seismographs ranged from 4 to 14 and totaled 500 seismograph weeks or an average of 9.6. There was one torsion balance at work in the state during most of the year. During the year there was one soil-analysis survey made in the Trapp pool area.

Considerable reconnaissance and detail surface structure mapping was done in the northeast part of Kansas and adjoining areas in conjunction with the Forest City basin lease play.

The geological departments of the companies were generally reduced during the year, many men being transferred to the Forest City and Illinois basin areas. Many of the Kansas independent geologists were likewise working in these areas.

NEW POOLS

Figures 1, 2, and 3 show the pools in western Kansas and as far east as R. 6 E. in eastern Kansas. The new pools are circled to distinguish them from the old pools.

EASTERN KANSAS

Developments as far east as R. 6 E. are here considered and in this area there were two new pools and several extensions and deeper zones developed.

NEW POOLS

Wilson pool.—Pryor and Lockhart *et al.* Wilson No. 2, NE., NW., NW., Sec. 9., T. 33 S., R. 6 E., Cowley County, was completed, producing 443 barrels natural early in December, 1938. The production comes from the Arbuckle dolomite from 3,514 to 3,517 feet and has a gravity of 41° Bé. At this time there are 3 completed wells in the pool.

Eastborough north pool.—This pool was discovered by the National Refining Company's Trustee No. 1, SE., NE., Sec. 8, T. 27 S., R. 2 E., Sedgwick County, in August, 1938. The well made a potential of 420 barrels after being shot and acidized at a total depth of 3,262 feet in the Viola limestone. Only one additional well has been completed since the discovery.

NEW PRODUCING ZONES IN OLD POOLS

Hittle pool.—The Hittle pool was discovered in 1926, the original production coming from a sand in the upper part of the "Kansas City" limestone at a depth of about 2,400 feet. In May, 1938, McKnabb and Blair's Hittle No. 1 in the SW., SE., NE., Sec. 21,

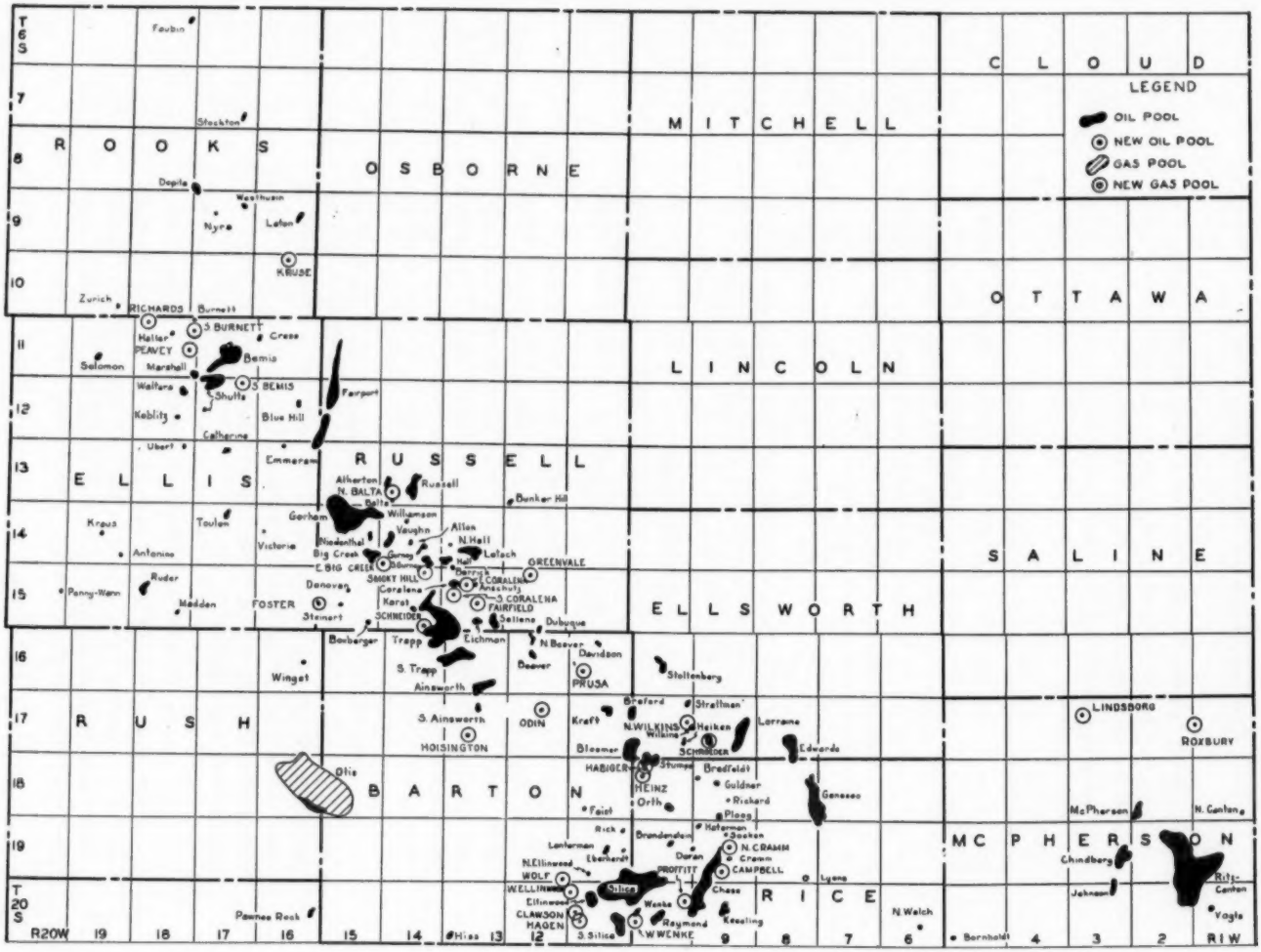

FIG. 1.—Oil pools in south central Kansas.

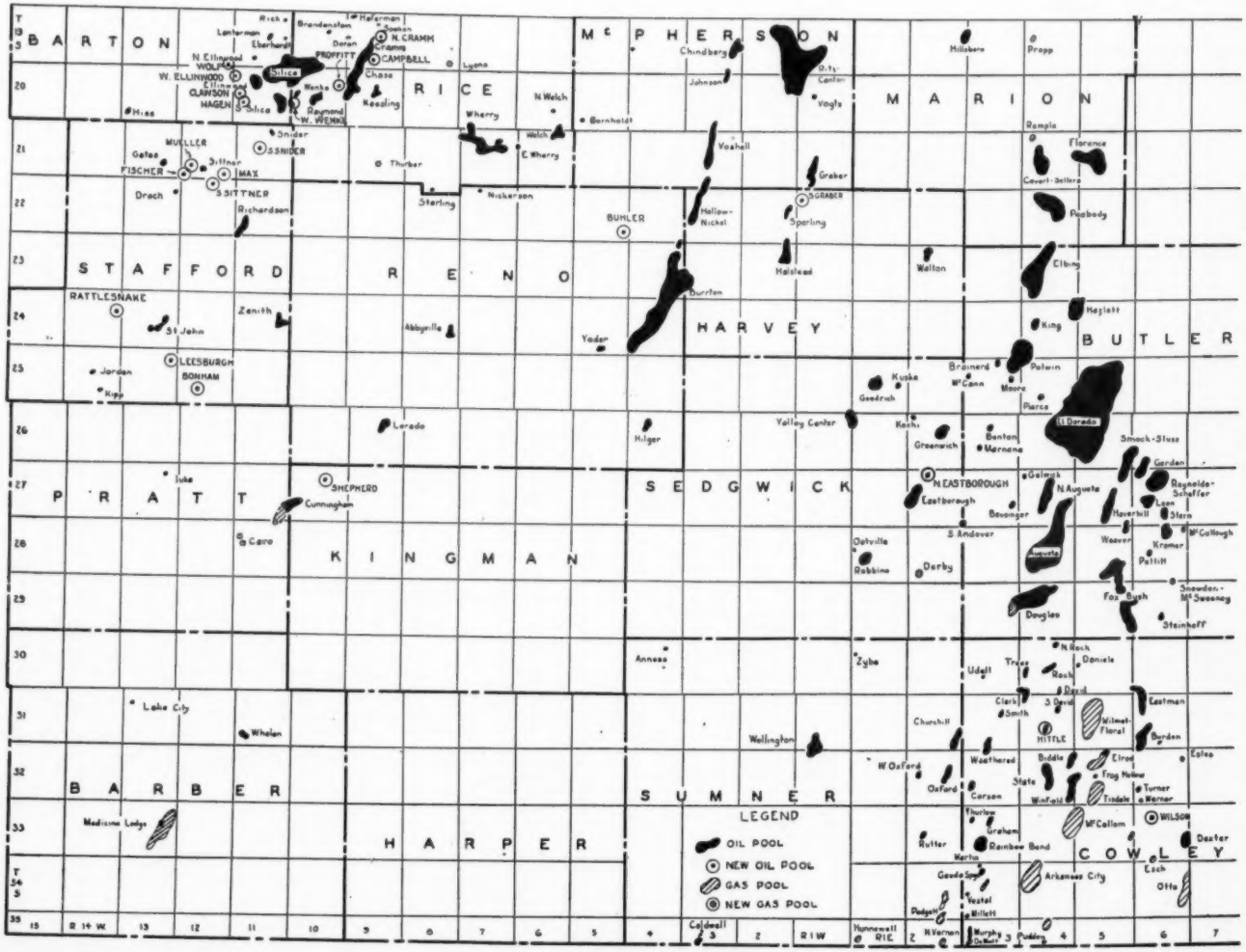

FIG. 2.—Oil pools in central western Kansas.

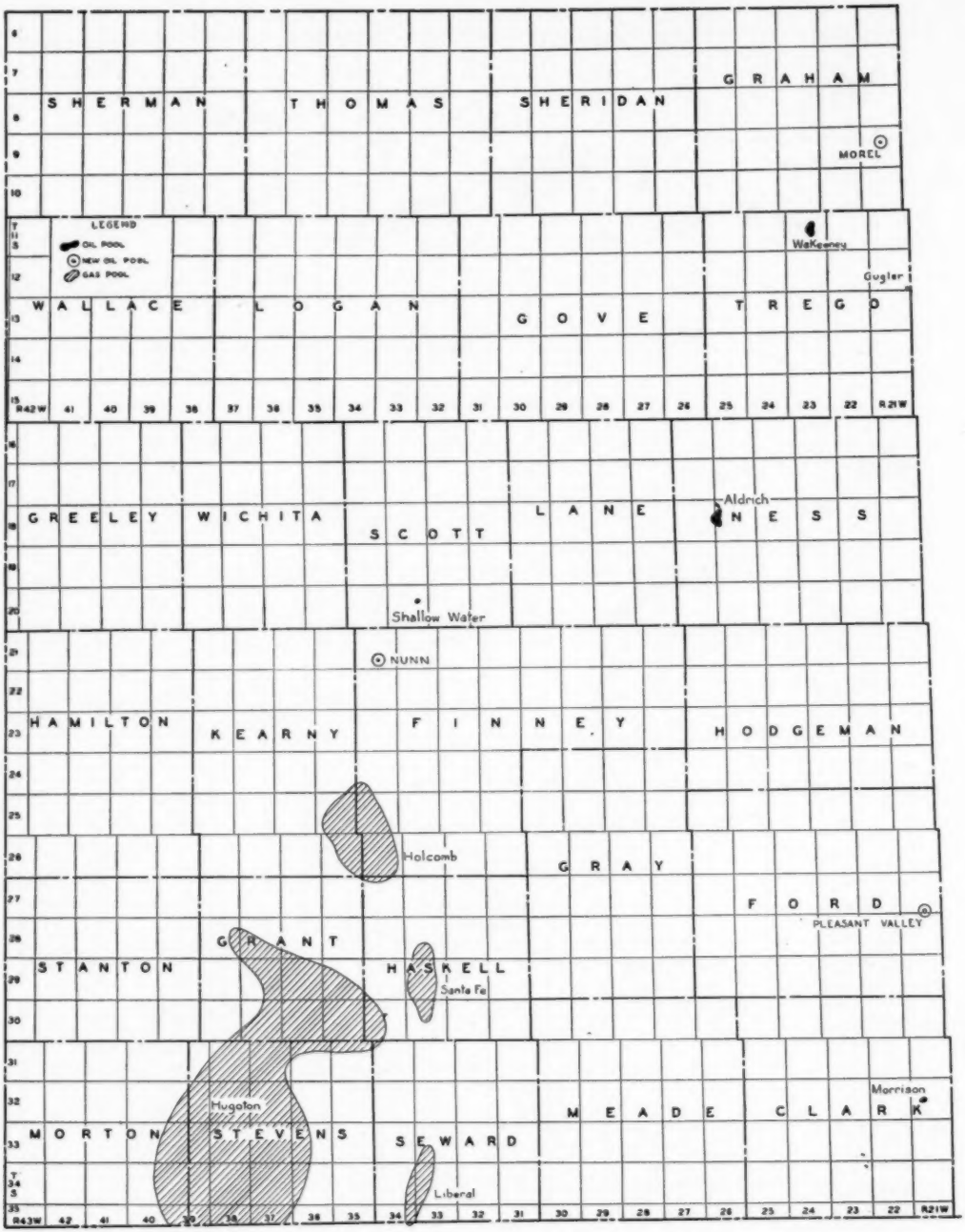

FIG. 3.—Oil pools in western Kansas.

T. 31 S., R. 4 E., found production in the Arbuckle dolomite from 3,280 to 3,288 feet and made a potential of 1,643 barrels natural. At the end of the year eight wells had been completed and the Arbuckle potential was 16,158 barrels. The pool is expected to cover several hundred acres. This discovery has been the cause of considerable wildcatting in Cowley County.

Weathered pool.—The Weathered pool has been producing from the Arbuckle dolomite and the Lansing-Kansas City limestone. Wakefield's Wilson No. 2, SE., NE., NW., Sec. 4, T. 32 S., R. 3 E., was completed, producing 3,124 barrels, after 4,000 gallons of acid, from the Mississippi limestone in July, 1938. The oil is coming from some place between 3,059 and 3,150 feet.

WESTERN KANSAS

Despite the curtailed activity in western Kansas in 1938 there were a number of new pools discovered and two new counties were added to the producing list. The active wildcatting which discovered these pools was caused chiefly by lease expirations. Probably the most important discovery of the year was that of the Morel pool in Graham County which extended the general producing area of western Kansas nearly 15 miles northwest. There was usually little or no development, beyond immediate offset obligations, in any of the newly discovered producing areas. All of the new pools are shown on the maps and only those considered most important from the viewpoint of their potential productivity or from their geologic significance are discussed.

NEW POOLS

Bemis south pool.—This pool was discovered by Cities Service Oil Company's Hall No. 1 D., in the center of NW. ¼ of Sec. 2, T. 12 S., R. 17 W., in December. The well made a potential of 765 barrels of 31° Bé. oil after 1,000 gallons of acid from a depth of 3,593 to 3,603 feet. It is quite possible that this pool may eventually be connected to the Bemis pool or the Shutts pool.

Burnett south pool.—This pool was discovered by Duwe and Farris' Hadley No. 1 in the SE., NE., SE., Sec. 12, T. 11 S., R. 18 W., Ellis County. Several good showings were encountered in the Lansing-Kansas City limestone and an attempt was made to complete the well in this zone but operating difficulties prevented this so the well was carried to the Arbuckle dolomite and completed at a depth of 3,333 feet, producing 1,266 barrels natural. This pool may join with the Burnett pool on the north and with the Peavey pool on the south. If this should be proved this area would rival the Bemis pool in area

and importance. Only four wells had been completed in this pool by the close of the year as there were no pipe-line connections. A producing structural relief of over 75 feet has been developed to date and the water level has not been found.

Cramm north.—Shell Petroleum Corporation's Cramm No. 1, center of the north line of the NE. ¼ of Sec. 15, T. 19 S., R. 9 W., is the discovery well of this pool. Production comes from the Arbuckle dolomite from 3,240 to 3,251 feet and the well was completed, producing 1,622 barrels natural. There were three wells in this pool at the close of the year with a gross potential of 3,474 barrels.

Ellinwood west pool.—This pool was brought in by Crown Petroleum *et al.* Schartz No. 1, SW., SE., NW., Sec. 7, T. 20 S., R. 11 W., which was completed as an Arbuckle dolomite producer for 474 barrels natural at a depth of 3,346 to 3,352 feet. Three other discoveries were made in this area during 1938 as follows: Kaiser, Newton *et al.* Hagen No. 1, southwest corner, Sec. 20, T. 20 S., R. 11 W., was completed in the Arbucke dolomite, producing 669 barrels natural at a total depth of 3,331 feet (Hagen pool); Crown Petroleum *et al.* Wolf No. 1, SE., SW., SE., Sec. 36, T. 19 S., R. 12 W., was completed in the Arbuckle dolomite, producing 502 barrels after 6,000 gallons of acid at a total depth of 3,374 (Wolf pool); and Virginia Drilling Company *et al.* Clawson No. 1, SW., NW., Sec. 17, T. 20 S., R. 11 W., was completed, producing 679 barrels natural in the Arbuckle dolomite at a total depth of 3,300 feet (Clawson pool).

Greenvale pool.—This pool is in Sec. 4, T. 15 S., R. 12 W., and was discovered by Jones and Shelburne's Kuhnle No. 1, SE., NW., Sec. 4, which was completed in March, 1938, producing 945 barrels natural from the Lansing-Kansas City limestone. The producing zone is from 3,035 to 3,045 feet in the 60-foot zone. Four wells were completed in this pool during the year. In November, 1938, Jones and Shelburne's Kuhnle No. 1 A., NW., NE., SW., Sec. 4, T. 15 S., R. 12 W., found production in the Gorham sand at a depth of 3,282 to 3,288 feet. This well was completed, producing 194 barrels after having been given a 2,500-gallon acid shot.

Habiger pool.—This pool, which was reported as the Stumps Lansing-Kansas City pool last year, was expanded this year and Arbuckle dolomite production was found. Vickers Petroleum Company's Roesler No. 1, northwest corner of the SW. ¼ of Sec. 5, T. 18 S., R. 10 W., was completed in June, producing 2,278 barrels natural from the Arbuckle dolomite at a depth of 3,197 to 3,202 feet. The three offsets to this well were the only additional Arbuckle dolomite wells completed in this pool during the year.

Lindsborg pool.—The Carter Oil Company discovered this pool in

their No. 1 Hoglund, center of the west line of SW., NW. of Sec. 8, T. 17 S., R. 3 W., McPherson County, in February, 1938. The producing zone is the Viola limestone at a depth of 3,347 feet. The well was drilled to the Arbuckle and plugged back, and completed, producing 345 barrels of oil and some water after 2,000 gallons of acid. This is apparently not a very prolific area but is discussed because it is about 12 miles from the nearest production.

Peavey pool.—The Darby Petroleum Company's Peavey No. 1, northwest corner of the NE. ¼ of Sec. 24, T. 11 S., R. 18 W., is the discovery well of this pool. Peavey No. 1 was completed at a total depth of 3,455, or 30 feet in the Arbuckle dolomite, producing 1,367 barrels after being shot and acidized. As mentioned under the South Burnett pool, this area in T. 11 S., Rs. 17, 18 W., has prospects of being a large producing area comparable to the Bemis pool as there is a producing structural relief of over 75 feet developed in the area to date and no water has appeared.

Buhler pool.—The Amerada and Westgage-Greenland's Johns No. 1 in the southeast corner of Sec. 25, T. 22 S., R. 5 W., Reno County, is the discovery well of this pool. The discovery well was completed at a total depth of 3,902 feet in the Simpson sand for a potential of 912 barrels natural. The pool had only two wells in it at the close of the year and is mentioned only because it is producing from the Simpson sand which is not a common producing zone in the area.

Leesburgh pool.—This pool was discovered by the Continental Oil Company's Fair No. 1 at the center of the north line of the SW. ¼ of Sec. 12, T. 25 S., R. 13 W., in March, 1938. The producing zone is the Arbuckle dolomite which was found at a depth of 4,154 to 4,163 feet. The discovery well was the only one in this pool at the close of the year but since that time, as the pool has been extended a mile southeast by a well that is 126 feet higher structurally, it appears that this may develop into a sizable pool.

Sittner south pool.—Several new producing areas in the vicinity of the Sittner pool were discovered during the year. The Sittner south pool is in Sec. 3, T. 22 S., R. 12 W.; The Max pool is in Sec. 35, T. 21 S., R. 12 W.; the Fischer pool is in Sec. 31, T. 21 S., R. 12 W., and the Mueller pool is in Sec. 29, T. 21 S., R. 12 W. All of these pools produce from the Arbuckle dolomite.

Morel pool.—The Continental Oil Company's Morel No. 1 is the discovery well of this pool. It is at the center of the west line of the east half, NE. ¼ of Sec. 15, T. 9 S., R. 21 W., Graham County, and was completed for 2,105 barrels natural from the Arbuckle dolomite at a depth of 3,711 to 3,720 feet. This discovery is important because it extends the general producing area westward about 15 miles. The

gravity of the oil, however, is only 27°–28° Bé.; therefore, the area is not as attractive as it would be with a higher-gravity oil.

Nunn pool.—This pool was discovered by the Atlantic Refining Company's Nunn No. 1 in the center of the SE. corner, NE. ¼ of Sec. 27, T. 21 S., R. 34 W., which was completed for 604 barrels, after being shot with 60 quarts of nitroglycerine and acidized with 16,000 gallons of acid, in the Mississippian from 4,632 to 4,718 feet. As this well is about 10 miles southwest of the Shallow Water pool it is the most westerly in the state.

EXTENSIONS TO OLD POOLS

The most active development in any pool throughout the year was in the Zenith pool which had nearly 100 wells drilled in it during the year and the area extended a mile north and 1½ miles east. The December runs from this pool were 74,168 barrels and the pool potential the first of January, 1939, was 208,238 barrels, the daily allowable being 0.86 per cent of the potential.

The Bemis pool was extended east and southeast during the year and was the site of considerable drilling early in the year.

The Trapp south pool had considerable drilling in it during the year and the Schneider pool is an important outpost discovery west of the Trapp pool.

The east side of the Geneseo pool was rather actively developed during the year. The Edwards pool, northwest of the Geneseo pool, was extended north one mile by two outpost discoveries.

There was only a moderate amount of drilling in the Silica and Gorham areas during the year.

NEW PRODUCING ZONES IN OLD WESTERN KANSAS POOLS

The Lake City pool in Barber County was discovered in 1937, as a Viola limestone producer. In September, 1938, production was found in the Arbuckle dolomite by Pryor and Lockhart's Gant No. 1 C, in the northeast corner of Sec. 18, T. 31 S., R. 13 W., at a depth of 4,607–4,611 feet. The well was completed with a potential of 1,211 barrels after a 3,000-gallon acid shot. The gravity of the oil is 42° Bé. This discovery is important because it proves the existence of oil in the Arbuckle a long distance south and west of any other Arbuckle production.

The Vaughn pool was a 1937 Lansing-Kansas City limestone discovery. In May, 1938, the National Refining Company's Reinhardt No. 1, in the southeast corner of the NE. ¼ of Sec. 19, T. 14 S., R. 14 W., found production in the Gorham sand after being dry in the Lansing-Kansas City limestone. The well was completed, producing 725 barrels from a depth of 3,282 to 3,289 feet, with a gravity of 34° Bé.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE, 1939), PP. 807-822, 3 FIGS.

RECENT DEVELOPMENT IN ILLINOIS WITH DISCUSSION OF PRODUCING FORMATIONS BELOW McCLOSKY "SAND"[1]

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ABSTRACT

The recent discovery of Devonian oil production in the old Sandoval field has focused attention on Devonian possibilities in the Illinois basin. As yet there has been relatively little testing of pre-Ste. Genevieve formations in the region. This paper reviews the known occurrences in Illinois of oil in the Mississippian below the Ste. Genevieve and in the Devonian, Silurian, and Ordovician systems.

A brief statement regarding developments in Illinois during 1938 and up to the early part of March, 1939, is included.

INTRODUCTION

During the 12-month period from March 1, 1938 to March 1, 1939, the rate of oil production in Illinois has mounted rapidly from a daily average of 43,000 barrels to one of 160,000 barrels—nearly a 4-fold increase. This increase has been due almost entirely to the development of fields on the western side of the Illinois basin, producing from sandstones in the lower part of the Chester (Upper Mississippian) series. The previous development during 1937 had been mainly in the central part of the basin where production to date is nearly all from the Ste. Genevieve oölitic limestone (McClosky "sand") in the upper part of the Iowa (Lower Mississippian) series.

A discovery which may have much significance in future development was made in December, 1938, when oil production was obtained in Devonian limestone in the old Sandoval field of Marion County, Illinois, which had been producing for 30 years from the Benoist sand of the Chester series. This article includes a discussion of developments during the 12-month period, and a review of the known occurrences of oil in Illinois in strata below the McClosky.

DEVELOPMENT IN 1938

An index map of new fields and extensions discovered during 1938 and the first 2 months of 1939 is shown in Figure 1.

In the last two years 23 new pools were discovered in Illinois, 8 in 1937 and 15 in 1938. Four new pools were discovered during the first two months of 1939. Following the presentation of the paper at the annual meeting of the Association three additional pools were discovered to April 4.

[1] Read before the Association at Oklahoma City, March 23, 1939. Manuscript received, April 15, 1939.

[2] Illinois State Geological Survey, Urbana; published with permission of the Chief.

With the new development in the state production has been obtained from three formations which were not productive in the old fields. A sandstone in the Paint Creek formation is productive in the Louden (Beecher City) pool. It has locally been called the "Stray" sand. The Aux Vases sandstone, the basal formation of the Chester

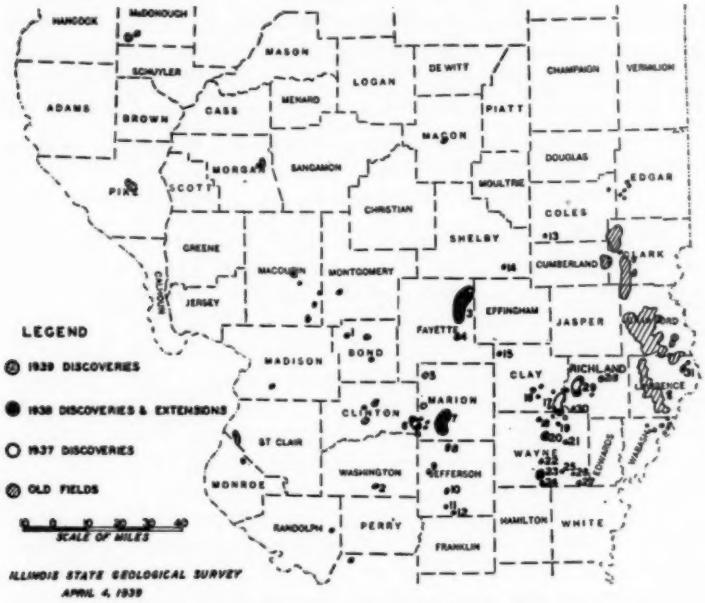

FIG. 1.—Index map showing old and new oil and gas fields in Illinois. The new fields are as follows: (1) Sorento; (2) Cordes; (3) Louden (Beecher City); (4) St. James; (5) Patoka; (6) Centralia; (7) Salem (Lake Centralia); (8) Dix; (9) Roaches; (10) Marcoe; (11) Elk Prairie; (12) Ina; (13) Mattoon; (14) Stewardson; (15) Iola; (16) Flora; (17) Clay City; (18) Rinard; (19) Enterprise; (20) Cisne; (21) Mt. Erie; (22) Boyleston; (23) North Aden; (24) Aden; (25) Barnhill; (26) Golden Gate; (27) Leech Township; (28) Olney; (29) Noble; (30) Schnell; (31) Russellville gas. Numbers 16 to 30 inclusive are referred to collectively as the Central Basin fields.

series, is productive in the Salem (Lake Centralia) and Cisne pools and in the recently discovered Iola pool. The Rosiclare sandstone member of the Ste. Genevieve formation is productive in the Roaches pool in west-central Jefferson County. Tables I and II list the producing strata in the state and the approximate depths to the producing formations in the new fields.

The course of development in this 14-month period in four producing areas, which include about 97 per cent of the production from

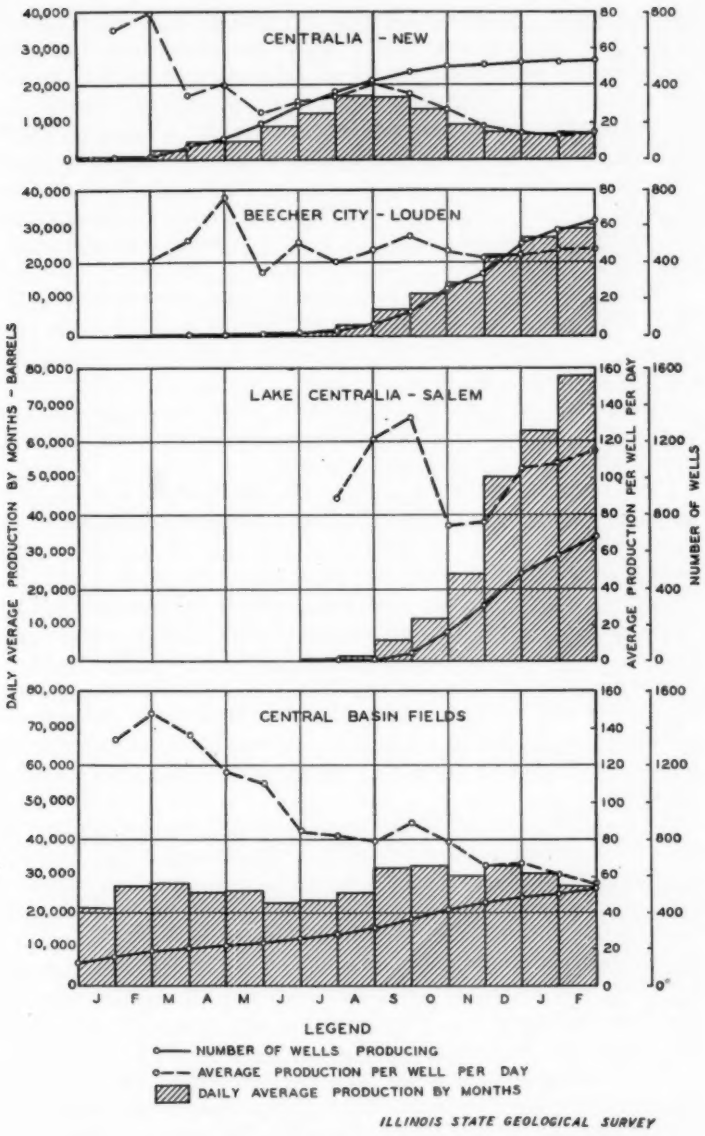
CENTRALIA - NEW
BEECHER CITY - LOUDEN
LAKE CENTRALIA - SALEM
CENTRAL BASIN FIELDS
DAILY AVERAGE PRODUCTION BY MONTHS - BARRELS
AVERAGE PRODUCTION PER WELL PER DAY
NUMBER OF WELLS
J F M A M J J A S O N D J F
LEGEND
NUMBER OF WELLS PRODUCING
AVERAGE PRODUCTION PER WELL PER DAY
DAILY AVERAGE PRODUCTION BY MONTHS
ILLINOIS STATE GEOLOGICAL SURVEY

FIG. 2.—Oil production and number of producing wells in four new producing areas of Illinois, January, 1938–February, 1939.

the new fields, is shown by Figure 2. For each of the four areas three sets of data are sl.own graphically: (1) the number of producing wells at the end of each month; (2) the daily average production by the month; and (3) the daily average production per well each month.

The data for this last curve were calculated by dividing the daily average production for each month and for each field by the number of producing wells in the field at the end of the month. This involves an error which is small in comparison with the figure obtained but the results are useful as an indication of the trend in average production per well in each area.

There is an upward trend in the total production rate of the new fields during the 14-month period, an increase each month in the number of producing wells, and a generally downward trend in the average production per well.

The upper three graphs are of fields producing almost entirely from sandstone, and the lowermost graph is a composite of fields producing almost entirely from limestone.

The central basin fields, producing from limestone, had their initial development in the spring of 1937, previous to the period of the graph, and their daily production had already reached 21,000 barrels, from 126 wells. During most of the period of the graph the flush production of the new wells was hardly more than sufficient to offset the decline of the previous wells. This was interrupted in August, September, and October, 1938, when the North Aden field, Wayne County, was being developed. The trend of the average production per well has been downward during most of the period from a high of 148 barrels to a low of 52 barrels. There was very little artificial restriction of production in this area during the period of the graph.

Of the three areas producing from sandstone for which graphs are shown, the earliest to be developed was the Centralia (New). Pipeline proration was introduced in this pool in April, 1938, and has been in force in varying degree ever since. Because this field is located partly within the city limits of Centralia, there was very rapid drilling development, and a peak of production was reached in August, 1938. The rate of production declined for the following 6 months. The close spacing of the wells in part of the area within the city limits is already leading to early abandonment of some of them.

The Louden (Beecher City) field, Fayette County, had a rather slow development up to August, 1938, after which the rate of drilling and the daily production increased rapidly. The rate of drilling was retarded somewhat in January and February, but the production

continued to increase, and the average production per well rose slightly. Because pipe-line proration has been in effect in this field from the beginning the curve of the average production per well can not be regarded as representing natural conditions.

The Salem (Lake Centralia) field is outstanding among the new fields of Illinois. At the end of the period of the graph (February 28, 1939) it was producing more than half of the total oil of the state. When it is remembered that the discovery well of the field was completed July 6, 1938, the exceptionally rapid development is apparent. The curve representing number of wells by months is seen to be the steepest of the four areas represented. At the end of February, 1939, there were 676 wells producing a daily average for February of approximately 78,000 barrels, or an average of 115 barrels per well per day. The curve representing daily average production per well does not show an overall downward trend; on the contrary it shows a rise during the last 5 months represented in the graph. Pipe-line proration in varying amounts has been in effect almost from the beginning.

Principal development to date in the Salem field has been in the Benoist sand (Chester series). However, two other formations, the Aux Vases in the Chester and the McClosky, are yielding some production and may be productive over most if not all of the area of Benoist production. The possibilities of production below the McClosky in this area remain to be explored.

PRE-MCCLOSKY PRODUCTION

With the widespread development in Illinois attention has been focused upon the potential oil strata below the McClosky "sand." To date the development in Illinois has been largely limited to the McClosky and higher formations because of the cost of deeper exploration and the small amount of structural information regarding the lower formations. Production has been obtained from strata below the McClosky in various areas in Illinois. A discussion of these areas follows.

A well, recently drilled to the Devonian in the Sandoval field, Marion County, created much interest in Devonian-Silurian possibilities in other areas in the state. The well was drilled on the crest of the dome and reached the Devonian limestone at a depth of 2,876 feet, producing from 2,920 to 2,926 feet. A second well, a dry hole, was drilled to the Devonian at the northeastern edge of the old productive area and found the top of the Devonian 125 feet lower than in the discovery well one-half mile southwest. A third well which was

TABLE I

Oil and Gas Producing Strata in Illinois

System or Series	Formation and Lithology*	Local Name and Area Productive
Pleistocene		Gas from glacial drift
Pennsylvanian	McLeansboro - sh., ss., thin ls., and coal	Upper Siggins, "Gas" - Clark County fields
	Carbondale - sh., ls., ss., coal	Casey, Claypool, Upper Partlow, Lower Siggins, "Bellair 500" - Clark County Dykstra, Wilson - Marion County
	Pottsville - ss., sh., and thin coal	Lower Partlow - Clark County Robinson - Crawford County Bridgeport - Lawrence County Buchanan - Lawrence County Biehl & Jordan - Wabash County Petro - Marion County
Chester (Upper Mississippian) Series	Kinkaid - ls., sh. Degonia - ss. Clore - ls., sh. Palestine - ss. Menard - ls., sh. Waltersburg - ss. Vienna - ls., sh. Tar Springs - ss. Glen Dean - ls., sh. Hardinsburg - ss. Golconda - ls., sh. Cypress - ss. Paint Creek - ls., sh. Bethel - ss. Renault - ls., sh., ss. Aux Vases - ss.	Carlyle - Clinton County Kirkwood - Lawrence County Upper Lindley - Bond County Weiler - Richland and Fayette Counties Stray - Fayette County Tracey - Lawrence County Benoist - Clinton, Fayette, Jefferson and Marion Counties Aux Vases - Marion County Bradley - Wayne County
Iowa (Lower Mississippian) Series	Ste. Genevieve - ls. (Levias - ls., Rosiclare - ss., Fredonia - ls.) St. Louis - ls. Salem - ls. Warsaw - ls. Keokuk - ls. Burlington - ls. Fern Glen - ls. (Osage group) Kinderhook - sh., ls., ss.	Rosiclare - Jefferson County McClosky "sand" - Illinois basin and southeastern fields Westfield lime - Clark County "Mississippi Lime" Carper sand - Clark County
Mississippian and Devonian	Chattanooga - New Albany sh.	
Devonian	Limestone	"Niagaran" Martinsville pool - Clark County "Hoing sand" Colmar-Plymouth field - McDonough County
Silurian	Dolomite	(Hunton limestone of Oklahoma)
Ordovician	Maquoketa - sh. Kimmswick - ls. Plattin - ls. Joachim - ls. St. Peter - ss.	"Trenton" Westfield pool - Clark County Dupo field - St. Clair County (Viola limestone of Oklahoma) (Wilcox sand of Oklahoma)

*ls. - limestone; ss. - sandstone; sh. - shale

TABLE II

Approximate Depths to Principal Producing Horizons in Illinois Oil Fields*

Geologic system or formation			Colmar-Plymouth	Dupo	Carlyle-Bartelso	Centralia	Lake Centralia - Salem	Dix	Patoka	St. James	Beecher City - Louden	Central Basin Area	Southeastern Illinois
PENNSYLVANIAN		Pottsville											Robinson and Bridgeport sands 1000' Buchanan - 1250'
MISSISSIPPIAN	Chester	Cypress			Carlyle sand 1000'	Cypress 1200'				Weiler 1600'	Weiler sand 1510'	Weiler sand 2600'	Kirkwood sand 1500'
		Bethel				Benoist 1350'	Benoist 1770'	Benoist 1950'	Benoist 1420'		Benoist 1540'		Tracey sand 1600'
		Aux Vases					Aux Vases 1800'					Bradley sand 2990'	
	Ste. Genevieve	Fredonia					McClosky "sand" 2000'					McClosky sand: Clay City 2980'; Noble 2960'; Olney 3050'; Schnell 3010'; Flora 2970'; Cisne 3120'; Aden 3290'; N. Aden 3310'; Leech Twp. 3450'	McClosky "sand" 1700'
DEVONIAN			Hoing sand 450'										Martinsville pool "Niagaran" 1550'
ORDOVICIAN				"Trenton" 500'									Westfield pool "Trenton" 2260'

* Several fields, having only one to four wells each, are not included.

also dry was drilled ¼ mile west of the first well and the top of the Devonian limestone was found to be 75 feet lower.

Evidently, there was little or no shifting of the structure with depth. Also, the structure becomes sharper with depth and has a

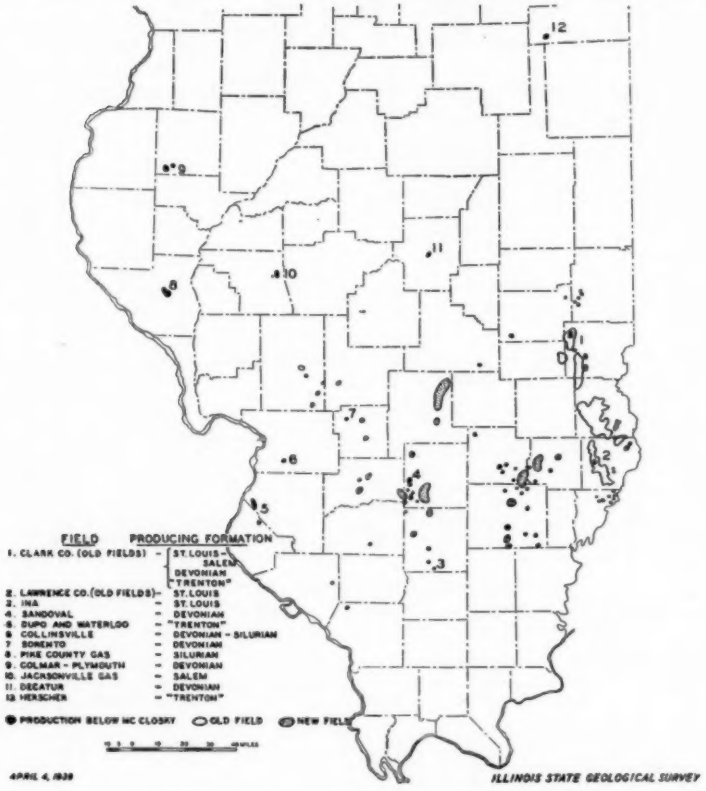
FIELD PRODUCING FORMATION
1. CLARK CO. (OLD FIELDS) - ST. LOUIS - SALEM DEVONIAN "TRENTON"
2. LAWRENCE CO. (OLD FIELDS) - ST. LOUIS
3. INA - ST. LOUIS
4. SANDOVAL - DEVONIAN
5. DUPO AND WATERLOO - "TRENTON"
6. COLLINSVILLE - DEVONIAN - SILURIAN
7. SORENTO - DEVONIAN
8. PIKE COUNTY GAS - SILURIAN
9. COLMAR - PLYMOUTH - DEVONIAN
10. JACKSONVILLE GAS - SALEM
11. DECATUR - DEVONIAN
12. HERSCHER - "TRENTON"
PRODUCTION BELOW MC CLOSKY
OLD FIELD
NEW FIELD
APRIL 4, 1939
ILLINOIS STATE GEOLOGICAL SURVEY

FIG. 3.—Index map of areas of production from formations below McClosky (Ste. Genevieve formation, Lower Mississippian).

smaller area of production than the overlying Bethel sandstone. It is believed that similar structural conditions will be found on other structures in the Illinois basin.

The discovery well of the Louden (Beecher City) field, the Carter Oil Company's Mary Miller No. 1, Sec. 12, T. 8 N., R. 3 E., first produced oil from the Devonian, but since the production was very

small, it was plugged back to the Cypress sandstone from which it is now producing. The well is located at the northeastern edge of the structure and is within the area of production of the overlying Chester formation.

Another well to the Devonian was drilled about the same time as the Sandoval discovery. The DeMayo *et al.* Dressor No. 1, Sec. 21, T. 6 N., R. 4 W., Bond County, drilled on the flank of the Sorento dome, made a small producer in the upper part of the Devonian from 1,800 to 1,830 feet. The well was drilled higher on structure and about ¼ mile north of an old well which had a good showing of oil in the same zone. Owing to unfavorable weather and road conditions there has been no further development in this area. It is expected that this discovery will stimulate interest in western Illinois.

Production in the Lower Mississippian below the McClosky is practically limited to areas in which there is a marked erosional unconformity at the top of the Lower Mississippian. However, there are a few exceptions and more may be found. Zones of dolomite and dolomitic limestone are very common in the Ste. Genevieve, St. Louis, and Salem limestones. These zones are very persistent and can be traced in wells throughout the Illinois basin. The porous zones may carry salt water and may also have small oil showings. The Leach Brothers' Albert Lee No. 1, Sec. 11, T. 1 S., R. 10 E., Edwards County, had a showing of oil in one of these porous dolomitic zones in the Salem limestone. In Lawrence County high on structure two or three wells on the Bowers and Ross lease, Sec. 29, T. 4 N., R. 12 W., obtained production from a dolomite zone at the top of the St. Louis limestone, and 200 feet below the top of the Ste. Genevieve.

Another area of St. Louis production of considerable interest is the Nollem Oil and Gas Company's Kelley No. 1, Sec. 25, T. 4 S., R. 2 E., Jefferson County, which obtained production at a depth of 3,002 feet, 100 feet below the top of the St. Louis limestone. Production is in a porous zone in the fossiliferous limestone which is of very local occurrence. Wells drilled north and south of the discovery well were dry.

SOUTHEASTERN ILLINOIS FIELD

To date production below the McClosky sand in the southeastern Illinois oil field is practically limited to the northern part in Clark County. The Westfield limestone, which is the main producing formation of the Westfield pool, underlies the Pennsylvanian at a depth of 400 feet and includes the St. Louis and Salem limestones of the Lower Mississippian series. A well drilled in Sec. 17, T. 11 N., R. 14

W., logged 75 feet of St. Louis limestone overlying the Salem limestone. It is estimated that approximately 50 feet of St. Louis is present on top of the dome. Most of the production is obtained from the upper 50 feet of the limestone whereas on the sides of the dome it may be as much as 100 feet below the top. Very little production has been obtained at greater depths in the limestone. There are from one to three pays in dolomitized, slightly oölitic, pure or impure limestone zones. The range in porosity is very wide owing to the varying degree of dolomitization and oölitic content. Very porous streaks are usually less than 10 feet thick and vary from 10 to 100 feet apart.

The "Trenton" (Kimmswick-Plattin) limestone which is geologically the oldest producing formation in Illinois, is productive in 11 wells near the top of the Westfield dome. The limestone is reached at a depth of about 2,270 feet and the pay was found in the upper 150 feet of the limestone. The oil occurs in pure crystalline limestone which is more porous in the lower part. The wells had a flush production of approximately 100 barrels after shooting, but within two or three months dropped to 10 or 12 barrels a day on pump.

The St. Peter sandstone was tested on structure in the Tidewater Associated Oil Company's Spellbring No. 34, Sec. 8, T. 11 N., R. 14 W. The top of the sand was reached at 2,984 feet; the well was drilled to 3,009 feet.

In the Westfield pool the structure is a broad, well defined dome with about 180 feet of closure on the eroded top of the Lower Mississippian limestone and about 300 feet of closure on the top of the "Trenton." The top of the "Trenton" structure appears to be about ¼ mile west of the top of the structure on the Mississippian limestone.

In the Martinsville pool the St. Louis limestone which immediately underlies the Pennsylvanian is productive. Locally the pay stratum has been called the Martinsville "sand." It is in the porous, somewhat altered zone in the limestone usually from 5 to 10 feet below the top and averages 20 feet in thickness.

The Carper sand, consisting of one to four sandstone lenses, each 10 to 30 feet thick, is in the lower Osage group. The sandstones are fine-grained and occur in lenticular beds of variable thickness and considerable areal extent. Each bed is separated by 10 to 15 feet of shale. The top sand is usually barren of oil and the second sand is the principal producer. Much gas was produced with the oil near the crest of the structure.

Mylius (1)[3] considered the Carper sand upper Kinderhook in age and Moulton (2) placed the sand "in the black shale underlying the

[3] For references, see end of article.

Mississippian limestone." Later studies in the Martinsville field by L. E. Workman and J. N. Payne[4] show that the Carper sand is basal Osage. All of the sandstones that have been called the Carper sand occur above the Rockford limestone which is near the top of the Kinderhook in this part of Clark County. A sandstone may be present in certain areas beneath the Rockford limestone, but it is of local occurrence and very thin.

The Devonian-Silurian limestone which has been called "Niagaran" and "Corniferous" is productive in the Martinsville pool. Production is from the weathered zone in the upper part of the limestone and the best production is found 10 to 30 feet from the top. Much water has been produced with the oil from this zone.

The "Trenton" has been tested in two wells, both on the west slope of the structure, one of which was dry. The other produced a small amount of oil from a coarsely crystalline limestone, somewhat sandy toward the base. The producing well on the McFarland farm, Sec. 19, T. 10 N., R. 13 W., was drilled 125 feet into the "Trenton" limestone, reached at a depth of 2,708 feet. The Lowe dry hole was drilled in Sec. 25, T. 10 N., R. 14 W. The top of the "Trenton" was reached in this well at a depth of 2,709 feet.

The structure in the area is an elongate dome on the side of and somewhat parallel with the major fold of the LaSalle anticline. There is a closure of 20 feet on top of the eroded St. Louis limestone and less than 100 feet on the top of the Devonian. The Trenton Rock Oil Company's Carper No. 13, Sec. 30, T. 10 N., R. 13 W., total depth 3,411 feet, was drilled to the St. Peter sandstone, the top of which was reached at a depth of 3,400 feet.

In northern Crawford County the Salvage Oil and Fuel Company's W. S. McGrillis No. 6, Sec. 25, T. 8 N., R. 13 W., had a good showing of oil and gas in the Devonian limestone topped at a depth of 2,775 feet, total depth 2,785 feet. This well has created considerable interest in the possibilities of deeper production in Crawford County where the principal producing horizon is the Robinson sand of Pennsylvanian age. Small production has been obtained locally near Oblong, Illinois, in a deeper sand which has been correlated as the McClosky sand.

The Hastings *et al.* Athey No. 1, Sec. 18, T. 8 N., R. 12 W., a few miles northeast of the McGrillis well, tested the Devonian and had a fair showing of oil. Southeast of Stoy, Illinois, and within the producing area of the Robinson sand, the Zanhizer *et al.* Jones well tested the "Trenton" limestone in Sec. 12, T. 6 N., R. 13 W. The top of the

[4] Personal communication.

Devonian was reached at the depth of 2,896 feet, the "Trenton" at 4,243 feet, and the total depth of the well was 4,620 feet. Showings of oil were reported in the Devonian at 2,900 feet and 3,130 feet. It is expected that several tests will be drilled to the Devonian in the near future. To date these three wells are all that have been drilled to the Devonian in Crawford County.

Lawrence County has likewise had very little deep drilling. A well drilled in the Middaugh farm in Sec. 32, T. 4 N., R. 12 W., tested the St. Peter sandstone. This well was drilled on the axis of the anticline, 1½ miles southeast of the crest as mapped on the Kirkwood sand. There was a showing of oil in the Devonian limestone at 2,965 feet. The top of the "Trenton" was 4,370 feet, the St. Peter sandstone 5,180 feet and the total depth 5,190 feet. No showings were recorded below the Devonian. Another well was drilled to the Devonian within the area of production but toward the south edge in the Lawrence County field. The L. Jenner, Central Refining Co. No. 21 in Sec. 35, T. 3 N., R. 12 W., was drilled to a depth of 3,515 feet. Two showings of oil were recorded in the Devonian limestone which was topped at 3,145 feet—one showing at 3,303 feet and the other at 3,348 feet. Another well was drilled to the Devonian at the eastern edge of the county and a number of miles from production; no showings were recorded.

Wabash County has had no wells that were drilled to the Devonian or deeper.

JACKSONVILLE GAS FIELD

Much of the gas and a small amount of oil has been produced from the Mississippian limestone in the Jacksonville gas field 2 miles east of Jacksonville, Illinois. Some gas has been produced from the Pennsylvanian sandstone, as well as from the underlying Mississippian limestone, correlated as the Salem (9). The principal production is from a porous dolomitic zone near the top of the limestone. The field, abandoned in 1937, had more than 50 gas wells. The gas was used for heat and light in local residences and was also piped to the city of Jacksonville. A few wells are still being used by the landowners.

The structure of the beds beneath the Pennsylvanian unconformity is not known in detail because the wells in the area were drilled only a short distance into the limestone. However, it is possible that the form of the erosional surface may have been controlled by the folding of the underlying Mississippian strata. Contours on the erosional surface at the top of the limestone show a high in Secs. 2 and 3, T. 15 N., R. 9 W., where gas was produced. Oil was found lower

structurally on saddles between structures. A well was drilled to the "Trenton" in Sec. 8, T. 15 N., R. 9 W., in one of the areas of gas and oil production. The well was drilled 148 feet in the "Trenton" and no showings were recorded in the Devonian or "Trenton" limestone. The top of the Warsaw shale and limestone is reached at a depth of approximately 400 feet in this area; this is the shallowest horizon below the unconformity suitable for a key horizon for structure testing. The Salem limestone is only 100 to 150 feet thick in the field.

COLMAR-PLYMOUTH FIELD

In 1914 oil was discovered on the Hoing farm in Sec. 16, T. 4 N., R. 4 W., McDonough County. The field was rapidly developed and resulted in two separate producing areas; one largely in Secs. 15 and 16, T. 4 N., R. 4 W., which has frequently been called the east pool and the other to the southwest in Secs. 19 and 30, T. 4 N., R. 4 W., and extending into the eastern edge of Hancock County. This pool has been referred to as the south pool. Four hundred seventy-seven wells have been drilled in the field and 2,416,000 barrels of oil were produced to the end of 1938.

The producing formation, the Hoing sand, is a lenticular sandstone averaging 21 feet in thickness, occurring in lenses at the base of the Cedar Valley dolomitic limestone and in depressions on top of the Maquoketa shale. In this area the Silurian is absent and the Devonian Hoing sand rests on the Ordovician Maquoketa shale. The character of deposition of the sandstone and subsequent erosion account for its irregular occurrence in the field.

Blatchley and Savage (4) considered the Hoing sand of Devonian age "Hamilton (?)" and later Morse and Kay (5) and Hinds (6) defined the "sand" as Silurian. After studying numerous sets of well cuttings from the field and adjacent area Workman (7) correlated the sand as Devonian in age because the sand grains of which the Hoing sand is composed are not present in the Maquoketa shale or in the Silurian which is present near by. The sand grains resembling those of the Hoing sand are found widespread in basal Devonian strata in Illinois.

The structure of the field as shown by the contours on the Colchester No. 2 coal consists of a dome with an east-west axis about half way between Comar and Plymouth and a terrace on the northeast edge of the dome 1½ miles east of Colmar. The dome and terrace have a combined closure of 60 or more feet. Production occurs on top and well down the side of the dome.

The "Trenton" limestone has been tested in a number of wells

drilled on the dome, but to date no well has tested the "Trenton" on the terrace where the east pool is located.

DECATUR FIELD

In 1922 and 1924 several oil tests were drilled to the Devonian limestone in the vicinity of Decatur, Illinois. The top of the limestone was reached at a depth of 1,950 feet to 2,000 feet. A number of the wells had showings of oil in the Devonian but not sufficient for commercial production. In 1937, two of the old wells in Sec. 33, T. 17 N., R. 2 E., and Sec. 5, T. 16 N., R. 2 E., a short distance northwest of Decatur, were cleaned out, acidized, and made small producers. The Devonian limestone is only 10 to 20 feet thick in this area. Contours on coal No. 5 show an anticlinal nose northwest of town with a northwest trend. Last year a dry hole was drilled in Sec. 30, T. 17 N., R. 2 E., to the St. Peter sandstone and was found to be higher on the structure than the above mentioned producing wells. Here the Devonian was entirely removed and no showings were recorded in the Silurian or "Trenton" limestones.

PIKE COUNTY GAS FIELD

Gas was discovered on the Pittsfield-Hadley anticline in 1886, but the gas field on the anticline west of Pittsfield, Illinois, was not developed until after 1905. Gas was found in the Niagaran dolomite of Silurian age. The producing formation is overlain by shale of Upper Devonian and Lower Mississippian age (10, 11). On the highest part of the structure the Upper Devonian shale lies directly below the Pleistocene. The average depth to the top of the producing zone is 265 feet. The gas wells were scattered over an area of almost 9,000 acres. The gas was used locally by the landowners to heat and light their residences. The structure is an elongate anticline with small domes along the main axis, each dome having 40 to 60 feet of closure. The main axis of the fold has northwest trend and extends from Lewis County, Missouri, through Adams, Pike, and into Greene counties, Illinois (13). A number of wells on structure have been drilled to the St. Peter sandstone which is reached at the depth of 750 to 800 feet.

COLLINSVILLE FIELD

Near Collinsville, Illinois, four wells were drilled in Sec. 8, T. 3 N., R. 8 W., Madison County, and found production in Devonian-Silurian limestone. The "sand" according to the driller's logs was 20 to 30 feet thick. The greater part of the sand is in the Silurian as the Devonian is represented by approximately 5 feet of calcareous sandstone. The wells were small and were soon abandoned.

Although the available data are insufficient to determine the nature of the reservoir, there is a suggestion that a structure of small areal extent gave rise to the accumulation. The "Trenton" has not been tested in the vicinity of the production.

DUPO AND WATERLOO OIL FIELDS

The Dupo oil field discovered in 1928 is located on the Waterloo anticline which has a north trend and extends from St. Louis, Missouri, to Waterloo, Illinois (12). The Waterloo field which was discovered 8 years prior to Dupo was of less importance. It had only 23 producing wells and all were abandoned by 1930. The producing horizon in both fields is a porous zone in the light brown, crystalline Kimmswick ("Trenton") limestone occurring at the top of the limestone at a depth of 500 feet. The wells are drilled 40 to 50 feet in the limestone. To date 242 wells were drilled in the field and approximately 950,000 barrels of oil have been produced. Town lot drilling at the north end of the field hastened the rapid decline of the wells in that area and all but 25 of the wells have been abandoned. A few wells have recently been drilled at the eastern edge of the field and found production in crevices in the limestone according to information from drillers. This development has caused a revived interest in the field.

Both the Dupo and Waterloo fields on the Waterloo anticline are located on separate domes with 100 feet or more of closure. The anticline is a long, narrow structure with a steep west dip and a gentle east dip. The fold dies out to the north under St. Louis and to the south a short distance south of Waterloo. Only 200 feet of Mississippian strata are encountered in wells on the anticline; the Devonian is absent and the Silurian is represented by 50 or 70 feet of dolomitic limestone. I. G. Lockwood's Dyroff No. 1, Sec. 26, T. 1 N., R. 10 W., located on the flank of the structure, tested the St. Peter sandstone.

HERSCHER AREA

An area of passing interest which produced some oil and gas from the "Trenton" is in Sec. 32, T. 30 N., R. 10 E., Kankakee County (14). Nine wells drilled in the north half of the section produced oil and gas for a short time before being abandoned. The largest well produced only ½ barrel a day. All wells produced some gas, the largest being 32,000 cubic feet per day. The "Trenton" was reached at a depth of 140 feet and it is not known at what depth below the top of the limestone the oil was reached. Several wells were drilled in the area, but few logs are available and the available data are not sufficient to explain the structural conditions which gave rise to this

local occurrence of oil off the flank of the Kankakee arch. There are several areas in northwestern Indiana along the Kankakee arch in which oil was produced from the "Trenton" (15).

CONCLUSION

In view of the numerous areas of Devonian and "Trenton" production in the state and the recent finding of Devonian production in the Sandoval field, the possibilities for new production below the McClosky "sand" deserve serious consideration. Up to the beginning of the recent development production from these strata amounted only to about one per cent of the state's total production. It is possible that they will be important producing zones in such fields as Louden (Beecher City), Salem (Lake Centralia), Centralia, Patoka, and certain central-basin fields. In the central-basin fields the depth of the Devonian is estimated to be 4,500 to 5,100 feet and the "Trenton" 5,900 to 6,500 feet.

ACKNOWLEDGMENTS

For certain areas discussed in the manuscript the writers wish to acknowledge use of information from the publications listed as references.

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BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE, 1939), PP. 823-835, 1 FIG.

DEVELOPMENTS IN OKLAHOMA DURING 1938[1]

E. F. SHEA[2]
Tulsa, Oklahoma

ABSTRACT

The year 1938 marked another twelve months' period during which the volume of newly discovered petroleum reserves in Oklahoma failed by a substantial margin to offset withdrawals.

Total production of oil for the state during 1938 was approximately 170,000,000 barrels, a decrease of 23 per cent from the total for the preceding year. There were approximately 2,000 wells completed during the year, representing also a decrease of 30–35 per cent from the total well completions for 1937. The seismograph continued to be the chief exploratory method employed in the search for new structures, but there was a 20 per cent reduction in the average number of crews as compared with the preceding year. The majority of these crews were engaged in closer detail work in areas already fairly intensively explored.

There was very little decrease in wildcat drilling operations. Of the 2,000 well completions 220, or 11 per cent, might be classified as exploratory wells. By far the greater number of these were located adjacent to producing pools in the central part of the state. As a result of the drilling of these 220 wildcat wells, 42 new producing areas were discovered. Of this total 16 might be considered as extensions to known pools and 26 as new pools. Thirty-nine of the discovery wells produced oil and 3 produced gas. Pennsylvanian sediments accounted for the production in 19 of the discoveries. Siluro-Devonian in 4 wells, and Ordovician in 19 wells.

It is unfortunate that by far the greater number of the discoveries reveal as yet only relatively unimportant reserves. The outstanding discoveries as indicated by development to date were the Ramsey pool, in Payne County, and the Alma Oil Company extension to the St. Louis pool, in Pottawatomie County. Developments subsequent to discovery around outlying wildcats at Noble, in Cleveland County, and at Hillsdale and Waukomis, in Garfield County, have been disappointing. Drilling activities in the older pools of the state were largely routine, with the Seminole-St. Louis areas furnishing the greatest number of completions. The Oklahoma City pool continued to lead the state in output, with an annual production during 1938 of 38,796,000 barrels. The Fitts pool with 16,655,000 barrels ranked second.

INTRODUCTION

The year 1938 was characterized in Oklahoma by a material decrease in activity in all phases of the petroleum industry. While this condition resulted, to some extent, from the transfer of attention to new operations in other states, it was no doubt largely due to the generally unsatisfactory economic conditions which affected business as a whole throughout the year.

PRODUCTION

Total production of oil for the state during 1938 was approximately 170,000,000 barrels, a decrease of 50,000,000 barrels, or more than 23 per cent from the total for the preceding year. Since the decline in Oklahoma production is equal to 78 per cent of the total decrease for the entire nation as compared with 1937, and is also more

[1] Read before the Association at Oklahoma City, March 23, 1939.

[2] Geologist, Stanolind Oil and Gas Company.

than twice the total amount produced by Illinois during the year, it is obvious that Oklahoma has suffered the major loss in the readjustment of state allocations.

The Oklahoma City pool continued to lead the state in output with an annual production during 1938 of 38,796,000 barrels. This compares with a peak production for the pool of 67,000,000 barrels attained during the year 1933. The Fitts pool with a total output of 16,655,000 barrels for the year ranked second in the state but reflected a very marked decline from the peak of 31,000,000 barrels produced during 1937.

DRILLING OPERATIONS

Complete and accurate information on the total number of well completions for the state during the year is not available. There appears to be no uniform system of reporting new wells, workovers and plugging-back operations, and much of the old producing area of the state is not closely scouted. Figures compiled from information at hand however indicate a total of approximately 2,000 wells completed during 1938, or about 35 per cent less than the total for 1937. Of the total completions for the year 60 per cent were oil wells, 8 per cent were gas wells and 32 per cent were dry holes. Drilling operations in the older proved fields were largely routine with the greatest number of completions reported from the general Seminole-St. Louis area.

Drilling at Oklahoma City was limited largely to the Dolomite zone at the north end of the structure with a number of plug-back completions to upper sands in the older part of the pool. Operations at Fitts were limited to workovers, a few Hunton lime completions along the north flank of the structure, and the development of some production from a shallow McAlester sand at the east end of the pool. The St. Louis-Maud area was particularly active in the extension of development in the Simpson dolomite, and in the Calvin, Senora, and Earlsboro sands of Pennsylvanian age. In the east end of the Cement pool in Caddo County some nice well completions from the Rowe sand created a slight renewal of interest in that area. Development of the deep Simpson oölite zone in the Fox area has been disappointing, only 4 producing wells and as many dry holes having been completed during the year.

EXPLORATION AND DISCOVERIES

Advance exploratory work was limited quite largely to routine subsurface studies, and seismograph work with a few torsion balances and gravity meters reported from the west and northwest part of the

state. There was some seismograph exploration along the north flank of the Wichita Mountains, in the Anadarko Basin, and in north-central Oklahoma west of Enid. Much of this exploratory work has been followed by renewed leasing activities. For the most part, however, the seismograph crews were engaged in closer detail work in local areas in central Oklahoma within which repeated shooting had been previously done. During the year the weekly average number of crews at work in Oklahoma was 16.8, a reduction of slightly more than 20 per cent, as compared with the weekly average of 22 plus during 1937.

There was very little decrease in wildcat drilling operations during the year. Of the total, 2,000 well completions 220, or 11 per cent, might be classified as exploratory wells. By far the greater number of these were located adjacent to producing pools in the central part of the state. As a result of the drilling of these 220 wildcat wells, 42 new producing areas, or extensions to old producing areas were discovered. Of this total 16 might be considered as extensions to known pools and 26 as new pools. Thirty-nine of the discovery wells produced oil and 3 produced gas. Production in 18 of the new areas occurs in Pennsylvanian sediments, 1 minor extension in a gas pool is probably producing from the Permian. Ordovician formations account for production in 19 wells and Silurian-Devonian in 4 wells. Numerically the discoveries included exceed those of the past several years, but it is unfortunate that most of the new wells reveal as yet only relatively unimportant additional reserves, and no new stratigraphic or structural provinces were proved productive. Many of the so-called extensions represent merely a revival of drilling with proof of minor additional reserves in areas which have been inactive for several years. They are included in the discussion only as an indication of the trend of current exploratory work and not on account of their economic importance.

Absolute knowledge as to the geological information upon which exploratory wells were drilled is not available, but a probable classification would credit 4 of the discovery wells to surface indications, 15 to seismograph work, and the balance to subsurface data, trend, oil showings, and the usual wildcat driller's optimism.

In Table I are listed the wells drilled in Oklahoma during 1938 which are considered as discovery or extension wells, with pertinent data as to location, producing sand, initial capacity, *et cetera*.

On the accompanying map of Oklahoma (Fig. 1) are indicated by appropriate symbols the location and name of the new discoveries together with some of the more important wildcat dry holes completed

TABLE I

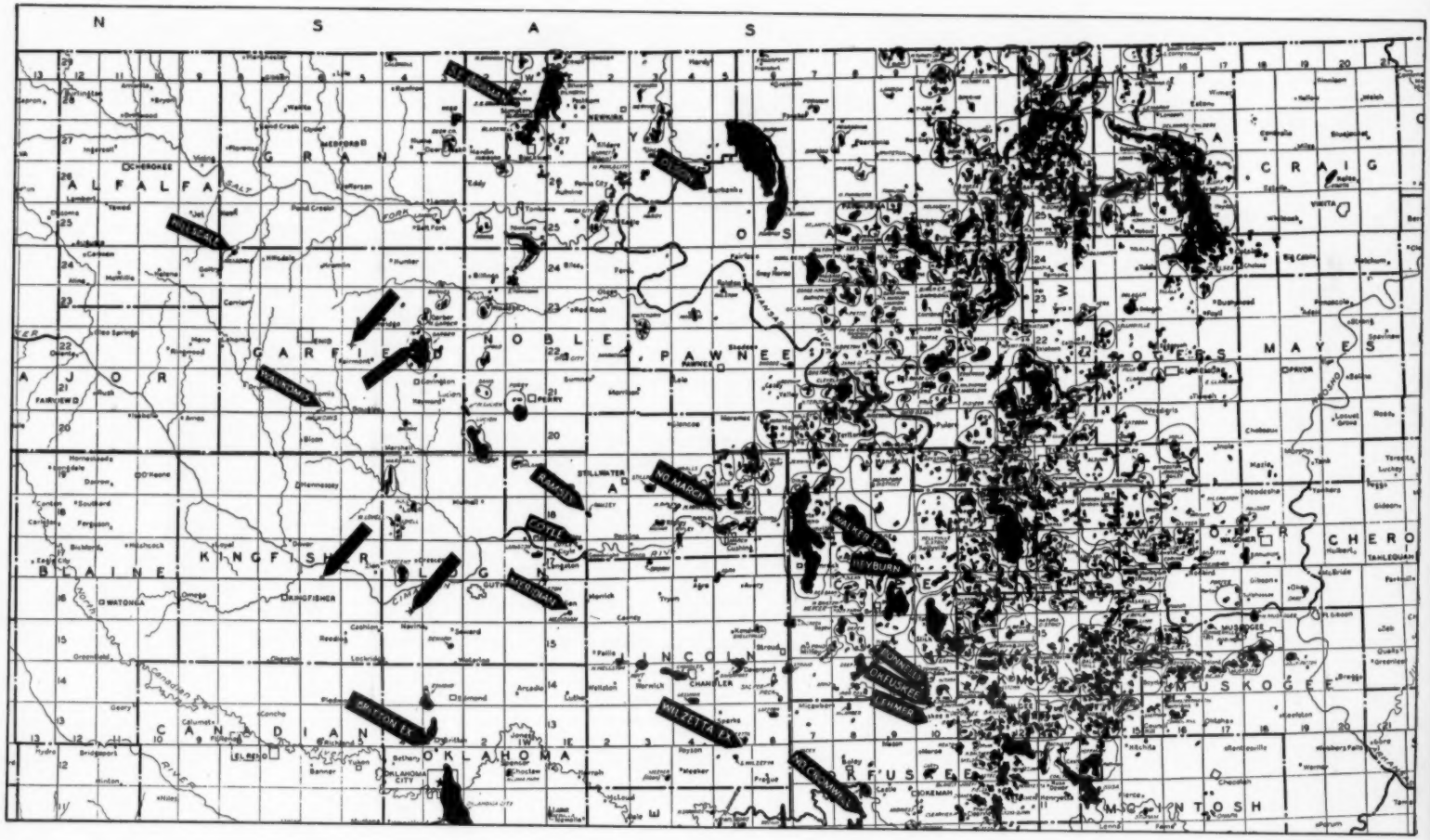
Discoveries in Oklahoma During 1938

Field	*County*	*Sec.-T.-R.*	*Operator*	*Well*	*Date of Completion*	*Producing Sand*	*Total Depth (in feet)*	*Initial Production*	*Development*
McGee (Extension)	Beckham	25-8N.-22W.	Wagner-Stegner		Oct., 1938	Sand	1,045	Gas	Old inactive gas area
Noble	Cleveland	12-7N.-2W.	Delaney	Bugher	May, 1938	Simpson	7,682	1,500/12 hrs. Show water	1 well; 2 dry holes
Heyburn (Extension)	Creek	36-17N.-9E.	McAdams, *et al*	McMahan	9-10-38	Dutcher	2,713	170	2 wells
Heyburn	Creek	7-16N.-10E.	McAdams, *et al*	Leverett	Dec., 1938	Bartlesville	2,335	35	2 wells; 2 drilling
Walker (Extension)	Creek	15-17N.-9E.	Central Com.	Bruce	9- 8-38	Bartlesville	2,550	Oil	5 wells; 2 drilling
Donelly (Extension)	Creek	28-14N.-10E.	Lease Inv. Co.	Miley	Dec., 1938	Misener	3,244	105	1 well
Hillsdale	Garfield	4-24N.-8W.	Champlin	Boehm	Sept., 1938	"Wilcox"	6,703	235 oil; 235 water	2 wells; 1 dry hole
Waukomis	Garfield	34-21N.-6W.	Hollenbeck	Clark	4-15-38	Simpson	7,336	240	1 well; 1 dry hole
Tussey (Extension)	Garvin	19-1N.-3W.	Skelly	Jones	11-19-38	Deese	3,920	24	1 well
Clark	Garvin	16-3N.-3E.	Edwards	Clark	4-18-38	Pennsylvanian	2,676	14 oil; 14 water	1 well; 1 dry hole
Calvin	Hughes	8-5N.-10E.	Phillips	Beeker	2-12-38	Viola P.B.	6,286	1,134/6 hrs.	1 well making considerable water
Fream	Hughes	29-9N.-9E.	Stano-Amerada	Fream	4-19-38	Wapanuka P.B.	4,268	138 oil; 7 M gas	2 wells
Wetumka	Hughes	13-9N.-10E.	Phillaine	Morrison	9-20-38	Simpson	4,214	80 oil; 160 water	1 well; 1 dry hole
S. E. Bramen	Kay	16-28N.-1W.	Helmerich-Payne	State	7- 1-38	Tyner	3,645	2,000/24	4 wells; 1 drilling
Wilzetta (Extension)	Lincoln	2-12N.-5E.	Indian States	Bailey	8-27-38	Hunton	4,244	73/5 hrs. some water	2 wells
Meridian	Logan	27-16N.-1E.	Sinclair-Prairie	Crews	8- 4-38	Marshall	5,238	455	1 oil well; 2 gas wells
Wynnewood	Murray	8-1N.-2E.	Gilbreath-Dalton	Wolfe	5-31-38	Simpson	2,622	35 M gas; spray oil	1 well
Britton (Extension)	Oklahoma	4-12N.-3W.	Olson	Vanek	10-14-38	"Wilcox"	6,778	288	1 well; 1 dry hole
Britton (Extension)	Oklahoma	21-13N.-3W.	Kerlynn	Orphanage	11-5-38	"Wilcox"	6,702	185	1 well
Olson	Osage	24-26N.-4E.	Olson Drlg. Co.	Indian Land	12-28-38	Prue	3,160	55	1 well; 2 dry holes
Lehmer	Okfuskee	21-13N.-10E.	Lease Inv. Co.	Fee	12-10-38	"Wilcox"	3,612	100	1 well; 1 drilling
Lehmer	Okfuskee	21-13N.10E.	Broswood	Lehmer	3-15-38	Dutcher	2,865	40	1 well
Cromwell	Okfuskee	26-11N.-8E.	C. W. Titus	Lehmer	8-27-38	Dutcher	3,485	132 oil; 15 water	1 well; 1 dry hole

TABLE I—*Continued*

DISCOVERIES IN OKLAHOMA DURING 1938

Field	*County*	*Sec.-T.-R.*	*Operator*	*Well*	*Date of Completion*	*Producing Sand*	*Total Depth (in feet)*	*Initial Production*	*Development*
Okfuskee	Okfuskee	10-13N.-10E.	Mid-Continent	Irelan	2-15-38	"Wilcox"	3,431	70	4 wells; 2 drilling
March (Extension)	Payne	6-18N.-5E.	Kemp, *et al*	Rafferty	6-25-38	Skinner P.B.	3,705	5 M gas	1 well
Ramsey	Payne	18-18N.-2E.	Mid-Con't., *et al*	Ramsey	1-12-38	"First Wilcox"	4,795	13,344	21 wells; 4 dry holes
Coyle	Payne	12-17N.-1E.	Texas	Longan		Simpson	5,006	455	3 wells; 1 dry hole
Fitts (Extension)	Pontotoc	23-2N.-7E.	Delaney	Horn	5-16-38	McAlester	1,277	64	10 or more oil; 2–3 dry
Avoca	Pottawatomie	6-6N.-4E.	Atlantic	McCurry	8-30-38	Viola & "Wilcox"	4,209	1,400	3 wells; 1 dry; 2 drilling
Maud (Extension)	Pottawatomie	16-8N.-5E.	Morgan & Flynn	School Land	12-10-38	Hunton P.B.	4,270	2,400	1 well; 1 drilling
Alma (Extension)	Pottawatomie	32-8N.-5E.	Alma Oil Co.	Smith	3-29-38	Dolomite & "Wilcox"	4,059	930 oil; 150 water	45 oil; 1 dry; 6 drilling
Rosanna (Extension)	Seminole	36-8N.-7E.	Rogers & Rogers	Robinson	10-22-38	Gilcrease	3,140	74	2 wells
Tyrola	Seminole	4-5N.-6E.	Arch Oil Co.	Collins	12-17-38	Trenton	3,270	278/1 20% water	2 wells
Hazel	Seminole	35-7N.-5E.	Villines	Reed	6-18-38	Earlsboro	3,005	75	9 oil; 3 dry holes
Grayson (Extension)	Seminole	7-6N.-6E.	Denver P. & R.	Mathis	7-23-38	Dolomite & Wilcox	3,842	120	5 oil; 4 drilling
W. Konawa	Seminole	27-6N.-5E.	Grisso	Roy Johnson	6- 4-38	Senora	2,714	240	6 oil; 3 dry holes
W. L. River	Seminole	17-7N.-6E.	Young-Newsom	Edgemin	9-10-38	"Wilcox"	4,380	887	5 oil; 5 drilling
W. Konawa	Seminole	34-6N.-5E.	Davis	Jones	4-12-38	Calvin	2,314	56 oil; 24 water	3 wells
Hazel	Seminole	26-7N.-5E.	Villines	Swan	5-10-38	Senora	3,005	140	6 wells
Beebe	Seminole	9-5N.-5E.	McLerman	Shaw		Hunton	3,234	38 19 water	1 well; 2 drilling
Swan (Extension)	Seminole	18-6N.-6E.	Delaney	Swan	5-28-38	Earlsboro	2,691	75	1 well; 5 dry holes
Marlow	Stephens	1-2N.-8W.	Olson	Johnson	8-13-38	Pennsylvanian P.B.	9,106 10,000	45	Sand 8,980–97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GRANT
GARFIELD
NOBLE
PAWNEE
OSAGE
MAYES
CRAIG
MAJOR
BLAINE
KINGFISHER
LOGAN
CANADIAN
OKLAHOMA
LINCOLN
PAYNE
CREEK
OKFUSKEE
MUSKOGEE
MCINTOSH
CHEROKEE
WOODS
WOODWARD
ENID
PERRY
STILLWATER
CHANDLER
OKMULGEE
TULSA
OKLAHOMA CITY
EL RENO
WATONGA
KINGFISHER
CRESCENT
GUTHRIE
MEDFORD
PERRY
STILLWATER
NO MARCH
MUSKOGEE
OKMULGEE
TULSA
OKLAHOMA CITY

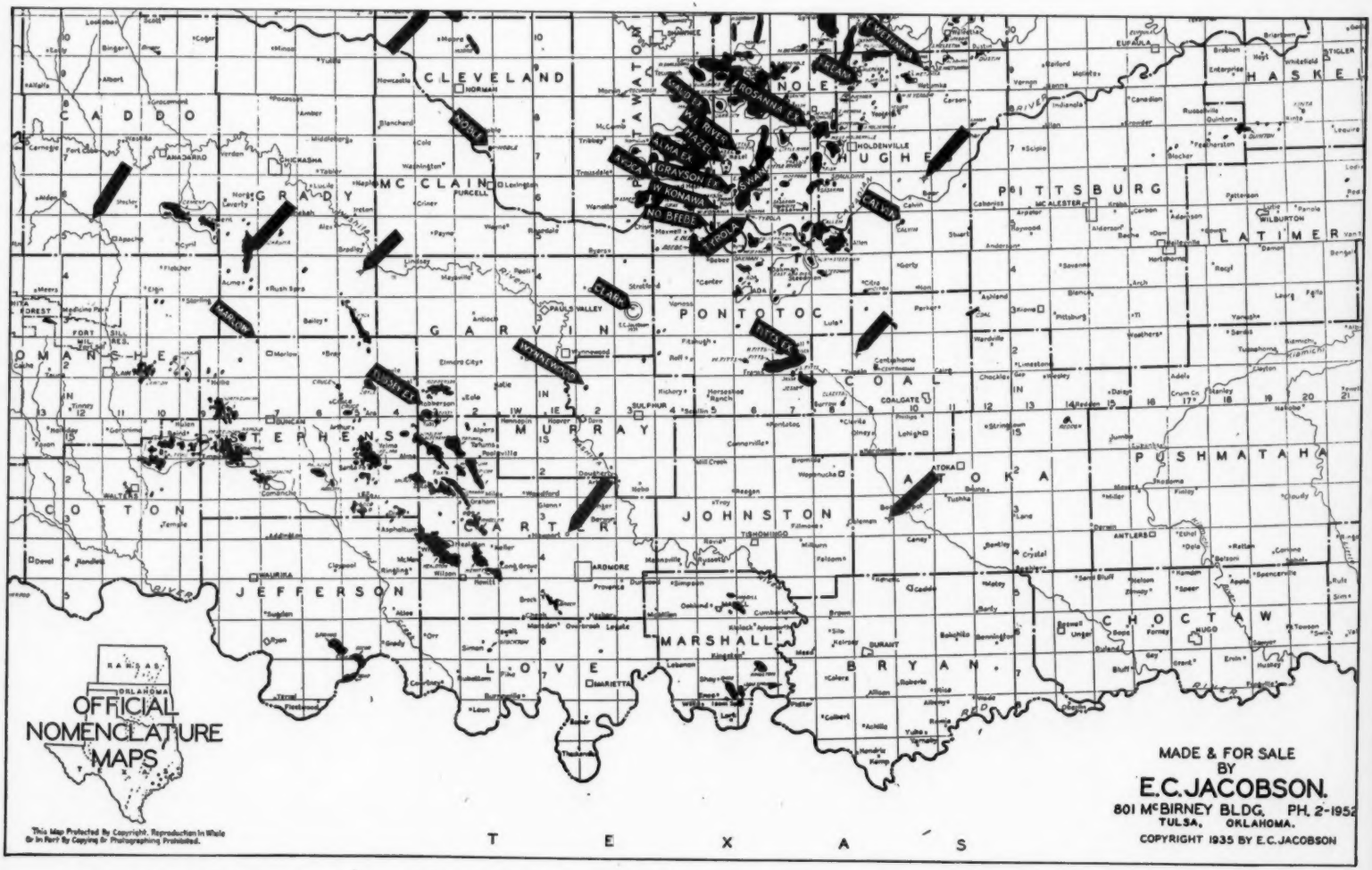

FIG. 1.—Map of Oklahoma showing new pools discovered during 1938 and indicating some of the more interesting wildcat dry holes and wildcat wells still active.

during the year, and a few of the interesting wildcat wells still drilling. Pool names in a few instances are not official but are used merely as a convenient reference.

It is apparent from the map that at least half of the discoveries are located within the Seminole plateau and along a narrow belt northward to the Cushing uplift. With one or two exceptions these wells have opened only minor extensions or small local pools with limited reserves.

INTERESTING NEW POOLS

Only a few of the more important wildcat discoveries will be given special consideration in this discussion.

The Ramsey pool.—This pool, in Section 18, Township 18 N., Range 2 E., Payne County, was perhaps the most important and remarkable pool discovered during the year. It was drilled on the evidence of local seismograph closure, in the center of a unit block of 640 acres embracing the W. ½ of Sec. 18, T. 18 N., R. 2 E., and the E. ½ of Sec. 13, T. 18 N., R. 1 E. By the end of February, 1939, a total of 21 producing wells had been completed, with average initial potential gauges of approximately 400 barrels per hour. All of the producing wells are located either upon or off-setting the W. ½ of Sec. 18.

The pool is defined on the west and the south by dry holes ¼ to ½ mile beyond production. A recent completion in the SW. Cor. of the NE. ¼ of Sec. 18 is low structurally and suggests a limit to further development in that direction. On the north and northeast the limits of production are still undefined, but the more gentle dips prevailing in those directions indicate many additional productive locations.

The Ramsey structure is not located along any of the previously known trends of folding or faulting. There is closure in excess of 200 feet on the producing sand. The uplift occurred largely during the early Pennsylvanian orogenic movement, as there is some thinning in the Cherokee and the "Mississippi lime" is entirely removed on the apex of the structure. There may be some expression of folding in the surface beds, but if so it was not generally recognized until after the pool was discovered. There may be faulting along the flanks of the structure but development to date furnishes no direct evidence.

In the general Cushing-Stillwater area, most structures producing from the Simpson have been somewhat disappointing on account of the inferior character of the reservoir sand and the limited productive range. The Ramsey pool is unique in producing through a vertical range of at least 150 feet and in having 30–40 feet of excellent porous sand with exceptionally good saturation. None of the producing wells

has encountered edge-water or bottom-water level. The Hunton limestone is present over the structure with a thickness of 30–50 feet. Good saturated cores and cuttings from the zone have been reported from nearly all wells drilled, but as yet no actual test has been made as to the commercial possibilities. The "Second Wilcox" sand is also present in the area but has not been penetrated by any well within the productive limits of the pool.

The Southeast Braman pool.—This pool was opened with the completion of the Helmerich and Payne State No. 1 in July, 1938, in the SW. Cor., SE. ¼, SW. ¼ of Sec. 16, T. 28 N., R. 1 W., Kay County, for an initial production of 80–90 barrels per hour from a sand in the Tyner at a depth of 3,595–3,645 feet. The three offsets to the discovery well have all been completed with fair initial capacities. There is no definite information as to the probable size of this pool although adjacent dry holes seem to indicate that it will be limited to a relatively small area. Accumulation appears to be controlled by a combination of favorable stragraphic trap and a small low fold in general alignment between the Braman townsite and Blackwell pools.

Of the 12 new areas opened during the year within the limits of the Seminole plateau, 5 are producing from sands of Pennsylvanian age. The sands represented are the Earlsboro sand in 2 wells, the Sonora sand in 2 wells, and Calvin sand in one well. Two new areas are producing from the Hunton lime and the remaining 5 from the Simpson, with the Trenton, the Dolomite and the "Wilcox" sand as the reservoir in one or more of the pools.

The most important discovery in the area was the Alma Oil Company extension to the St. Louis pool, in Sections 32 and 33, T. 7 N., R. 5 E., Pottawatomie County. Between 40 and 50 wells have been completed in this pool since the area was opened in March, 1938. Production is coming largely from the Simpson dolomite. Acidization is employed in the completion of the wells which ordinarily produce considerable water with the oil. Some of the more recent completions in the Alma pool have been finding commercial production in the "Second Wilcox" sand below salt water in the dolomite. The same condition is also found to prevail in the newly discovered Avoca pool in Sec. 6, T. 6 N., R. 4 E., and in the Grayson pool extension in Sec. 12, T. 6 N., R. 5 E.

With the exception of the shallow sand production at the east end of the Fitts structure only 1 new discovery was made during the year in the McAlester basin. In Sec. 8, T. 5 N., R. 10 E., near Calvin in Hughes County, the Phillips Petroleum Company, drilling Beeker No. 1 on a structure mapped by seismograph, found oil and gas in the

Cromwell sand at depths of 4,400–4,600 feet, oil and gas in the Viola-Trenton at 5,616–5,675 feet. The well was drilled to a total depth of 6,286 feet into basal McLish or "Wilcox" sand. After testing several showings in the Bromide and McLish sections it was finally completed in the Viola-Trenton. On an early test the well flowed 1,134 barrels in 6 hours with some water. Development is limited to the discovery well and additional drilling may reveal a pool of fair size. The Cromwell sand was not fully tested but will undoubtedly produce considerable gas with some oil.

Several wildcat wells drilled during the year beyond the limits of the producing area in central Oklahoma encountered production and bade fair to open extensive territory for immediate prospecting. Subsequent developments in every case, however, were disappointing and further drilling will be required to prove that these discoveries constitute commercial reserves. In the Noble area in Cleveland County, Delaney *et al.* Bugher No. 1, Sec. 12, T. 7 N., R. 2 W., drilled on evidence of surface structure, found oil in the sandy Dolomite zone above the "Second Wilcox" of the Moore pool at a depth of 7,682 feet. The well flowed at a rate as high as 150–200 barrels per hour but failed to maintain this potential for any considerable time and soon began making appreciable salt water. The well resulted in an intensive lease and royalty play, a resumption of detail seismograph work in the immediate area and the subsequent drilling of 2 dry holes, 1 located a mile north and the other about 1½ miles southeast. The discovery well now makes 125–150 barrels of oil and several hundred barrels of water per day.

In Garfield County 2 wildcat wells encountered oil production. The Hollenbeck *et al.* Clark No. 1, in the NW. Cor. of Sec. 34, T. 21 N., R. 6 W., near Waukomis, drilled on seismograph information, found the regular First and Second Simpson sands dry but had oil in a stray sand at 7,260–7,280 feet in the green shale section below the first sand. A dry hole offset which missed the pay zone has discouraged further development in the area.

In the Hillsdale pool Champlin Refining Company completed Boehm No. 1 in the NW. Cor. of the SE. ¼ of Sec. 4, T. 24 N., R. 8 W., in Second Simpson sand at a depth of 6,690–6,703 feet. The well made 225–250 barrels of oil per day and about the same amount of water. Offsets were immediately started on the south and on the northwest. The south offset has been completed for less than 100 barrels per day. The northwest offset was dry through the Simpson section into the Arbuckle limestone at a total depth of 7,203 feet and was abandoned. No other wells are drilling at this time.

INTERESTING DRY HOLES

It may be of interest here to mention briefly a few of the more interesting wildcat dry holes drilled during the year.

On the west flank of the Garber pool in the SE. Cor. of the SW. ¼, NW. ¼ of Sec. 13, T. 22 N., R. 4 W., Jones Associated Oil Company on the Wolfe Estate attempted to find truncated "Wilcox" sand but encountered Simpson below "Wilcox" at the unconformity, drilled into the Arbuckle and abandoned the well at a total depth of 4,626 feet. In Sec. 17, T. 22 N., R. 5 W., Garfield County, on a reported seismograph structure, I.T.I.O. completed the Kitchens No. 1 as a failure in the Simpson at a total of 6,954 feet. Along the trend between the Edmond and Crescent pools in Sec. 26, T. 16 N., R. 4 W., another attempt to find a granite ridge pool failed when Superior McCully No. 1 was abandoned at a total depth of 6,643 feet in the "Second Wilcox" sand. On the southwest flank of the Oklahoma City pool in Sec. 28, T. 11 N., R. 3 W., the Fain Drilling Company Little No. 1 reported favorable cores in the Simpson section but subsequent testing failed to reveal commercial production and the well was abandoned at a total depth of 7,006 feet.

In Grady County the Gulf Oil Corporation completed an interesting test when the Thomas No. 1 in Sec. 14, T. 4 N., R. 5 W., was abandoned at a total depth of 11,415 feet still in the Springer formation topped at 9,530 feet.

In the McAlester basin there were several unsuccessful attempts to discover new producing areas. At the eastern extremity of the Arbuckle Mountains, along the south flank of the Wapanuka graben, Stanolind Amerada Ridgeway in the NW. Cor., NE. ¼, NE. ¼ of Sec. 24, T. 3 S., R. 9 E., Atoka County, drilled on a seismograph structure, found no favorable showings through the entire Simpson section into Arbuckle lime at a total depth of 4,879 feet. Northwest of the Centrahoma structure Carter *et al.* Mote No. 1, in Sec. 19, T. 2 N., R. 9 E., encountered formations several hundred feet lower than the producing wells in the Centrahoma pool, and was abandoned as a failure at 7,374 feet in the McLish section. On a seismograph structure in Sec. 1, T. 6 N., R. 10 E., Hughes County, Phillips Petroleum Company attempted to repeat their success in the Calvin area, but the test well, Mandler No. 1, failed to find any commercial showings and was abandoned in the Arbuckle limestone at 6,153 feet.

WILDCAT WELLS STILL DRILLING

Among the wildcat tests which are still active at this time, a few seem worthy of mention.

In Kingfisher County, Trigg *et al.* are drilling ahead below 7,000 feet on their Lankard No. 1, an outlying wildcat in Sec. 34, T. 17 N., R. 6 W. In Sec. 28, T. 10 N., R. 20 W., Washita County, the Continental Proctor is drilling ahead below 10,300 feet. The test appears to be still in second granite wash at the total depth. The deep test in the Chickasha gas field, Carter *et al.* McGauhtry No. 1, in Sec. 26, T. 5 N., R. 8 W., is temporarily shut down at a total depth of 6,620 feet. Cores from the lower formations in this test showed dips as high as 80° and drilling operations were suspended pending the completion of some detail seismograph work in the area. In Sec. 2, T. 5 N., R. 12 W., The Texas Company Smith No. 1 is shut down at 2,556 feet in the Viola.

One of the most interesting wells drilling at the present time is the Pure Oil Company Noble No. 1 on the south end of the Caddo anticline in Sec. 35, T. 3 S., R. 1 E., Carter County. The test is drilling in Simpson at approximately 6,300 feet, about 1,300 feet below the top of the Viola limestone. The section of sediments encountered has been normal in sequence and thickness except for thinning in the Hunton limestone.

The well failed to find the steeply dipping beds, the thickening in the shale sections, and the general lack of conformity, which many had anticipated, assuming the Caddo anticline to be a superficial squeeze fold.

CONCLUSION

No attempt has been made for the purpose of this discussion to estimate the new reserves which may have been added to the Oklahoma total by the discoveries during the year 1938. A review of preliminary estimates made by the American Petroleum Institute's committee on petroleum reserves and by the *Oil and Gas Journal* reveals the fact that Oklahoma has again failed by a substantial margin to discover sufficient new reserves to offset the annual withdrawals.

There still remains within the state much untested territory in which new pools may be and undoubtedly will be discovered. The continued discovery of new extensions and minor pools within the province already producing, should serve to encourage the wildcatter, especially with such outstanding discoveries as the Ramsey pool to offer the occasional prize reward.

It is encouraging to note the relatively high percentage of outlying wildcat wells drilled in the western half of the state that have had oil at various depths in some appreciable quantity. Sedimentary condi-

tions are apparently favorable for oil accumulation but structural mapping is difficult. Proof of the reserves within this area must necessarily await the completing of more deep test wells. Under existing economic conditions, however, and with prospecting at more reasonable depths available in other areas, operators have been loath to tie up the necessary capital adequately to test western Oklahoma. It is hoped that a general business improvement, combined with the need of the state for additional reserves to maintain its market position, may in the very near future bring about a marked expansion in wildcat activities.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE, 1939), PP. 836-843, 1 FIG.

DEVELOPMENTS IN WEST TEXAS AND SOUTHEASTERN NEW MEXICO DURING 1938[1]

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AND SURCE JOHN TAYLOR[4]
Austin and Midland, Texas

ABSTRACT

The area covered in this paper extends westward from a line drawn north and south through San Angelo, Tom Green County, Texas, to include Eddy County, New Mexico, and southward from the north line of Cochran and Hockley counties in Texas to the Southern Pacific Railroad through Brewster and Terrell counties.

Drilling operations in the area during 1938 were 21.2 per cent less than in 1937. Additions to reserves consisted of four new discoveries, one rejuvenation and extensions to several existing fields. Wildcat and outpost operations were 23.4 per cent greater in the area than in 1937, but favorable results were somewhat limited. Southeastern New Mexico had 66 wildcats and outposts as against 43 in 1937 with two new discoveries and one rejuvenation. West Texas had 192 wildcat and outpost operations as compared with 166 during 1937, resulting in two new discoveries. Several fields in the area were extended, some of them vertically as well as laterally. A few of the outposts were definition wells, but the limits of some of the important fields are as yet unknown. Nearly all operations (89.6 per cent), were field wells.

Considerable core-drilling and geophysical prospecting was done in the area, especially in New Mexico.

Very little Ordovician testing was done during the year, and the results were negative.

Drilling operations in southeastern New Mexico and West Texas during 1938 were 21.2 per cent less than in 1937, and new field discoveries were few. Southeastern New Mexico had 16.2 per cent less operations of all classes but had 53.3 per cent more wildcats and outposts, which were responsible for many extensions of existing fields but included only 2 new discoveries. West Texas was off 22.5 per cent in total operations but had 15.7 per cent more wildcats and outposts with results almost identical with conditions in New Mexico. Of the 66 wildcat and outpost operations in New Mexico, 24 were completed as oil wells, 1 as a gas well, and 41 as dry and abandoned. The 192 West Texas wildcat and outpost operations produced 46 oil wells, 3 gas wells, and 143 dry holes. Southeastern New Mexico had 493 field wells drilled resulting in 465 oil wells, 16 gas wells, and 12 dry holes. There were 1,826 field operations in West Texas with 1,756 completed as oil wells, 10 as gas wells, and 60 were dry and abandoned. Because of more stringent proration rules and correspondingly less allowables, the pipe-line runs were less in 1938 than in 1937. This was especially noticeable in southeastern New Mexico where, in spite of the 489

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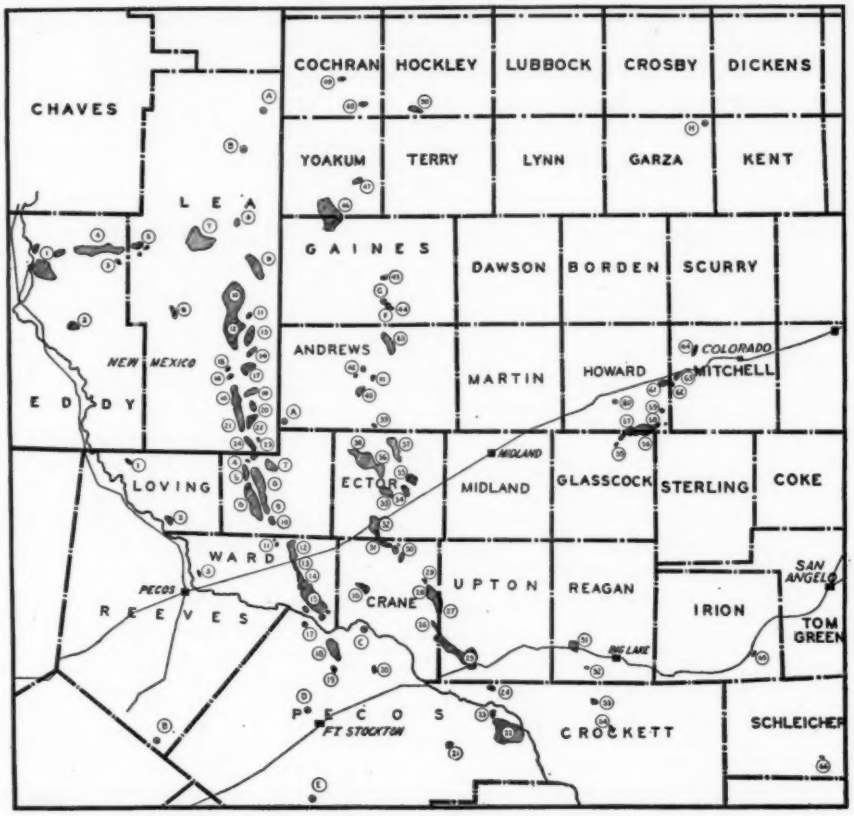

FIG. 1.—Base map of West Texas and southeastern New Mexico, showing location of fields and more important wildcats.

FIELDS

NEW MEXICO

1. Artesia
2. Getty
3. Shugart
4. Grayburg-Jackson
5. Maljamar
6. Lynch
7. Vacuum
8. Lovington
9. Hobbs
10. Monument
11. Skaggs
12. Eunice
13. Hardy
14. Penrose
15. South Eunice
16. Lynn
17. Skelly
18. Cooper
19. Mattix
20. Cooper Sand
21. Jal
22. Langlie
23. Rhodes
24. Eaves

WEST TEXAS

1. Kyle
2. Wheat
3. Monroe
4. Leck
5. Henderson
6. Hendricks
7. Keystone
8. Kermit
9. Brown-Altman
10. Halley
11. Magnolia-Sealey
12. O'Brien
13. North Ward
14. Estes
15. South Ward
16. Sand Hills
17. Netterville
18. Pecos Valley
19. Gregg
20. Masterson
21. Taylor-Link
22. Yates
23. Tobarg
24. Crockett
25. McCamey
26. Taylor-Hughes
27. Gulf-McElroy
28. Church-Fields
29. Dunes
30. Crane-Waddell
31. Jordan
32. Penwell
33. Harper
34. Addis
35. Foster
36. Goldsmith
37. North Cowden
38. Cummins
39. Emma
40. Fuhrman
41. Parker
42. Deep Rock
43. Means
44. Kirk
45. Seminole
46. Wasson-Denver
47. Bennett
48. Dean
49. Wright
50. Slaughter
51. Big Lake
52. Grayson
53. Powell
54. Todd
55. McDowell
56. Roberts
57. Settles
58. Chalk
59. Snyder
60. Moore
61. Denman
62. Dodge-Foster
63. Iatan
64. Westbrook
65. Mertzon
66. Page (gas)

IMPORTANT WELLS

NEW MEXICO

A. Rowan-Nichols, No. 1 State
B. Tide Water, 1-L State

WEST TEXAS

A. Perkins, Cowden
B. Ohio, Popham
C. Magnolia, McKee
D. Humble, Robertson
E. Thompson, Elsinore
F. Landreth, Dalmont
G. Finley & Cherry, Dalmont
H. Gulf, Swenson

additional producers, the pipe-line runs were 7.09 per cent off. In West Texas the total runs were 1.53 per cent less than in 1937.

Table I shows the production and drilling operation data in statistical form.

TABLE I

DRILLING AND PRODUCTION STATISTICS
WEST TEXAS AND SOUTHEASTERN NEW MEXICO
1938

A. PIPE-LINE RUNS IN BARRELS

District	*1937*	*1938*	*Decrease*	*Per Cent Decrease*
West Texas*	75,529,980	74,377,059	1,152,921	1.54
S.E. New Mexico**	37,955,579	35,264,147	2,691,432	7.09
Total area	113,485,559	109,641,206	3,844,353	3.38

* West Texas pipe-line runs are from West Texas Oil Scouts Report.
** New Mexico pipe-line runs are from Preliminary Report of New Mexico Proration Umpire.

B. DRILLING OPERATIONS

District	*Field Wells*				*Wildcats and Outposts*			
	Oil	*Gas*	*D & A*	*Total*	*Oil*	*Gas*	*D & A*	*Total*
West Texas	1,756	10	60	1,826	46	3	143	192
S.E. New Mexico	465	16	12	493	24	1	41	66
Total area	2,221	26	72	2,319	70	4	184	258

C. RATIO OF 1938 TO 1937 DRILLING OPERATIONS

District	*Field Operations*			*Wildcats and Outposts*		
	1937	*1938*	*Per Cent Change*	*1937*	*1938*	*Per Cent Change*
West Texas	2,438	1,826	−25.1	166	192	+15.7
S.E. New Mexico	624	493	−20.9	43	66	+53.3
Total area	3,062	2,319	−24.2	209	258	+23.4

Total West Texas operations — 2,018 or 22.5 per cent less than 1937
Total S.E. New Mexico operations — 559 or 16.2 per cent less than 1937
Total area operations — 2,577 or 21.2 per cent less than 1937

Two new discoveries are recorded for southeastern New Mexico that further development may show to be in the major field class. The Shugart area in Ts. 18 and 19 S., R. 31 E., was proved to be productive from two pay zones. The Shugart *et al.* Couthard No. 1 in Sec. 35, T. 18 S., R. 31 E., was drilled to a total depth of 4,088 feet, was plugged back to 3,970 and completed with an initial production of 125 barrels per day from the Artesia "Red sand" which was topped at 3,440 feet. The Carper Drilling Company, Day No. 1, in Sec. 3 T. 19 S., R. 31 E., was drilled to 2,748 feet, was plugged back to 2,697 and completed with an initial production of 54 barrels per day from the Yates sand. The top of the pay in this well was given as 2,675 feet.

Production in the south Lovington area was first indicated by a gas well. The Westmount, Amerada-State No. 1, located in Sec. 12, T. 17 S., R. 36 E., approximately 8 miles south and slightly east of Lovington, was completed as a 12 million-foot gas well on December 6, 1938. Three oil producers have been completed since January 1, and two wells are now being drilled. The production in this area is from the upper part of the San Andres.

A 3½-mile southerly extension of the Vacuum field was indicated during 1937 by the Texas Co., State 1-L in Sec. 1, T. 18 S., R. 34 E. This was verified by 1938 drilling. This field was also extended 3 miles east by the Phillips Petroleum Co., Santa Fe No. 6, in Sec. 21, T. 17 S., R. 35 E. Phillips Petroleum Co., State No. 7 in Sec. 27, T. 17 S., R. 35 E., extended the Vacuum field to the southeast. Both of these wells were true wildcats. Outpost drilling has since extended the field another mile eastward. The field has likewise been extended 3 miles westward.

The Continental Oil Company's State 1-J-2 in Sec. 2, T. 22 S., R. 36 E., indicated a 3-mile eastward extension to South Eunice. Further drilling tends to verify this, although the opinion has been expressed by some geologists that this may be a separate structure.

A New Mexico rejuvenation was the old Empire (now called Wilson) area in T. 21 S., R. 35 E. The original well in this area was drilled in 1928 but had been plugged and abandoned after producing 11,000 barrels. The Francis Wilson, State No. 1, in Sec. 7, T. 21 S., R. 35 E., was completed on October 27, 1938, at a total depth of 3,802 feet, yielding an initial production of 500 barrels per day from Whitehorse lime 300 feet below the top of the Yates. There has been one producer and one dry hole drilled in the area since that date, and one well is now being drilled. The areal extent of the structure is probably small.

Two northern Lea County wildcats, the Rowan-Nichols, State No. 1, center of NE. of NW. of Sec. 22, T. 10 S., R. 37 E., and the Tide Water, State 1-L, center of NE. of NW. of Sec. 23, T. 12 S., R. 36 E., apparently discounted two geophysically mapped high areas. The Rowan-Nichol, State No. 1 encountered 7 bailers of sulphur water per hour at 5,045–75. It had a small showing of oil at 5,041–45. The Tide Water, State 1-L was a failure at 5,294, encountering salty water from 5,254–94.

Activity in the sand pay zones of the Langlie and Rhodes fields brought these two fields closer together. Hardy, Penrose, Skelly, Mattix, and Langlie fields were each extended a small distance eastward.

Geophysical prospecting and core drilling in southeastern New Mexico was more extensive during 1938 than in any previous year. Twenty-seven core tests are recorded for the area, which is probably more than in all other years combined, if the U. S. Government potash tests are excluded. Although considerable seismographic and electrical-method wildcat exploration work was done in northern Lea and southern Roosevelt counties, probably the greater part of this geophysical and core-drilling activity was carried on to check acreage that was already under lease with expiration dates near.

West Texas had many active areas, but the results were mainly extensions of existing fields. Only two new fields of any importance were discovered during the year.

The Crockett field, in the southern part of Block 14, University Lands, in northwest Crockett County, has been fairly well defined in all directions except the southeast, and the present productive area is approximately 2,400 acres. The oil averages 28°–31°, and the production averages about 30 barrels per well. The pay zone is sand and sandy lime approximately 50 feet in thickness and is equivalent in age to the pay of the Yates field. The discovery well was Choate & Hogan, University 1-H, completed on April 20, 1938, with an initial production of 104 barrels per day.

The Dunes field, in the northwest corner of Block 30, University Lands, Crane County, has been defined on the east by dry holes, the Standard of Texas, University 4–1, and the Phillips, University-Crane No. 1; apparently on the southwest by the Magnolia, University 1–18; and on the south by the small producer, Magnolia, University 1–15. It is the opinion of many geologists that this field will extend to the northwest although no wells have as yet been drilled north of the north line of Block 30. The oil is of 35° gravity with very low bottom-hole pressures, and the wells drilled to date are pumper wells. The discovery well was the Magnolia, University 1–16, which was completed on May 25, 1938, with an initial production of 52 barrels, pumping. The average depth of production ranges between 3,150 and 3,250 feet. The pay zone is San Andres in age.

The Church & Fields area in Crane County was given a ½ mile northwest extension by the Gulf, State-L. E. Lassiter 2, the Humble, University 3-D, and the Tide Water, University 1-S-G.

The Jordan pool was extended ½ mile south by new Gulf-Henderson wells, and the gap between this pool and the Crane-Waddell is gradually closing.

In Andrews County the Means area was extended east by the

Humble, Means Nos. 49 and 51 which were large producers down dip on the east side of the Central Basin platform, and farther east was defined by the Humble, University 1-G in Sec. 18, Bl. 4, University Lands, a structurally low dry hole.

A previously considered northwest extension to the North Cowden pool has been indicated by subsequent drilling to be a separate structure and has been designated as the Emma pool. The present area of this pool covers the north half of Sec. 1, Bl. 44, T. 2 N. and the southern portion of Sections 35 and 36 of Bl. 10, University Lands. Its total extent is unknown, but it will very probably extend north and northeast.

In Ector County an interesting development in the north-central part of the county was the eastward extension of the North Cowden pool by the Texon Oil and Land Co. and Rushwold wells in Sec. 36, Bl. 43, T. 1 N. These wells were among the best wells in the field and produced from farther down dip but higher in the section than was previously generally considered probable and were responsible for considerable east extension drilling. The result of this drilling indicates a possibility of good production along the extreme east edge of the Central Basin platform. The structurally low, high-potential wells drilled by the Humble Company on the east edge of the Means pool in Andrews County apparently lend support to this theory. The Humble, University G-1 in Sec. 18, Bl. 4, University Lands, Andrews County, which was approximately ¾ mile southeast of the Humble's big producer (J. S. Means No. 49) and which was dry and abandoned at 4,942 indicates, however, that the marginal limits of this production will be somewhat sharply defined.

The Goldsmith field was extended both southeast and northwest.

The Foster pool was extended in all directions but principally to the east. The proved productive area of this field is now approximately double that at the close of 1937.

The Harper pool was extended ½ mile north during the year.

The Sinclair-Prairie drilled two wells (Moss Nos. 1 and 2) in Sec. 40, Bl. 44, T. 2 S., midway between the Harper pool and Penwell, that were not large enough to be commercial producers but did indicate a possibility of commercial production in this area.

Outpost drilling in south Ward and north Pecos counties brought in considerable new production along both sides of the Pecos River.

The Wasson-Denver field in Yoakum and Gaines counties was extended northwest, north, and northeast. The southwest extension of the Bennett Field by the Mabee, Willard No. 1 and the northeast

extension of the Wasson-Denver field by the Honolulu, Kendrick No. 1 indicate a possible future joining of these two fields which would make by far the largest field, in point of area, in West Texas.

What might be considered as a vertical extension was developed in the Seminole area of Gaines County by the Amerada, Riley No. 2. The original productive zone in this area was between −1,670 and −1,752 feet, sea-level datum, as was proved in the Magnolia, H & J No. 1 in Sec. 219, Bl. G, W.T.R.R. Survey. The Amerada, Riley No. 2 in the adjoining section Number 229 developed a new pay zone between −1,821 and −1,893 feet. Both of these zones are in the upper San Andres.

In Winkler County the Keystone pool was apparently extended ½ mile north and 2 miles northeast.

The 1938 development in Cochran County consisted of twelve wells. Six of these were field producers and six were wildcats. Two of the wildcats, in the Wright area, were producers, and the others were dry holes. All of these wells were completed in the San Andres at an average depth of about 5,000 feet.

The 1938 development in Hockley County furnished evidence that structural relief and reversals are present instead of the simple terrace conditions that apparently are the accumulation control features in some of the near-by areas. It is the belief of many West Texas geologists that Hockley County will develop a considerable amount of production.

Several wildcats and outposts were drilled in Howard County, but none were outstanding and the results were limited to extensions of existing fields, principally the Snyder area.

Not many of the 192 wildcats and outpost wells drilled in the West Texas area were of great significance except to the operators involved.

Two dry and abandoned wildcats in the Kirk area of Gaines County, the Landreth, Dalmont, in Sec. 24, Bl. A-12, and the Finley and Cherry, Dalmont, in Sec. 6, Bl. A-12, proved structure but no commercial production.

The American Liberty (Frank Perkins), Cowden No. 1 in the southwest corner of Andrews County was drilled to a total depth of 8,002 feet. The well was abandoned in limestone and shale which some geologists have claimed might be Mississippian in age. This test indicated a possibility that the early Paleozoic formations might not be too deep in this area.

In the Sand Hills area of Crane County it has developed that each well drilled is more or less of a wildcat. The results bear out the 1937 indication that the Ordovician in this area is steeply folded and

probably badly faulted. The Gulf, Waddell No. 9 showed considerable saturation in the Simpson which indicates a possibility of Middle Ordovician production.

The only other Ordovician development in West Texas during 1938 was the Magnolia, McKee No. 1 in Sec. 24, Bl. 9, H. & G.N. Survey, Pecos County, which was finally completed in the Ellenburger at a total depth of 6,267 feet. The top of Ellenburger was encountered at 6,102 or −3,717 feet. The Simpson was topped at 4,775 or −2,390, giving a thickness of 1,327 feet of this section which, except for the Humble, White and Baker in southern Pecos County that recorded 1,390 feet of Simpson, is the thickest Simpson section recorded in West Texas. A core from 5,274–94 feet showed saturation from 5,274–83 feet. Approximately one barrel of high-gravity oil per hour was swabbed from this zone but attempts to make a commercial producer failed. No worthwhile showings were encountered below this depth and the well was plugged and abandoned.

The projected Anderson and Prichard Ordovician test that is located in Sec. 104, Bl. 10, H. & G.N. Survey, between the Magnolia, McKee and the Fort Stockton high, will probably be one of the outstanding tests of 1939.

In the central part of Pecos County the Humble, Robertson No. 1 in Sec. 27, Bl. OW, T.C.R.R. Survey, topped the Delaware lime at a depth of 5,251 or −2,454. The importance of this well lies in its addition to definition control of the Delaware basin, marking the approximate southeast limit of this feature.

Operations were continued during 1938 on the Thompson, Elsinore Cattle Company well No. 1, which was an interesting 1937 wildcat, but no outstanding information was obtained other than that a very steeply dipping surface structure has apparently flattened to a considerable degree near the bottom of the hole which is at a present depth of 7,343 feet. The formation at the bottom is possibly Lower Permian. If this well is carried to its reported contemplated depth of 10,000 feet it may furnish some useful scientific information.

The Cooper, Bert Page No. 2, in Sec. 40, Bl. 1, G.H. & S.A. Survey, Schleicher County, ¾ miles southeast of the Cooper, Page No. 1 further proved the existence of a major gas field in this area. The gas is being produced from lower Canyon lime, possibly younger than Palo Pinto.

The Gulf, Swenson No. 1 in northeast Garza County indicates a possibility of deep production, possibly Strawn in age, in that area. Further information on this well has not as yet been made public.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE, 1939), PP. 844-859, 1 FIG.

DEVELOPMENTS IN NORTH-CENTRAL AND WEST-CENTRAL TEXAS, 1938[1]

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ABSTRACT

New developments and discoveries in north-central Texas during 1938 have materially increased the importance of the Strawn formations as major producing zones in the north-central district and have increased the scope of the Canyon and Cisco in the west-central.

The most important Strawn discovery in the north-central district was the Hull-Silk pool in north Archer County. Of smaller proportion, but highly significant, was the Adams Oil Company Moer No. 1 well near the town of Scotland which was completed from the Finley zone (one of the Hull-Silk pool zones) for approximately 115 barrels per day pumping.

Important extensions were made east and west of the K.M.A. field. The producing area was increased from about 10,000 acres in 1937 to 32,000 acres in 1938. This field, which was discovered in 1931 and had only five producing wells in 1935, began the year with 89 producers and ended with 890.

Sinclair-Prairie opened a new pool in the Delaware Bend area of Cooke County with its Best No. 1, and Rogers and Rogers another near the town of Nocona, Montague County, with the completion of their No. 1 Burnett. Both of these are lower Strawn in age.

Madden and Goldsmith and King Oil opened a new Canyon pool (Chalk Hill zone) in the Holliday district, Archer and Wichita counties. New Canyon production in Wilbarger County was also developed in the Castlebury pool from the Landreth limestone.

A small Bend pool was opened by Continental and Petroleum Producers on the State Asylum Lands on the outskirts of the town of Wichita Falls.

Important extensions to the James and Sims pools in southeast Young County, discoveries by Anzac Oil Company and R. V. Tidwell in southwest Young and the Wray pool in central Young served to keep interest active in the Bend areas of Young, Jack, and Throckmorton counties. A new feature of this area is the discovery of commercial Mississippian production in south Young County.

In the west-central district, two new pools, Irvin and Chittenden, were discovered in western Jones County in the Swastika sand underlying the Gunsight limestone, and new, deeper production was found in this zone in the Noodle Creek field. In eastern Jones County the Avoca pool, producing from the lower Canyon limestone (Avoca pay), was extensively developed. A new pool, the Griffin, was discovered in this same zone, and three new pools, Steffens, Fox, and Akard were discovered in shallower Cisco zones.

Although about the same number of wells were drilled in 1938 as in 1937, practically double the number of new pools and important extensions were reported. This was the result of more intensive application of geological and geophysical methods of exploration.

In spite of the larger amount of new production in 1938, the total production for the year was slightly less than in 1937. This was the direct result of the drastic proration conditions which were in effect during 1938.

[1] Read before the Association at Oklahoma City, March 23, 1939.

[2] District geologist, Continental Oil Company. The writer wishes to express his appreciation for the invaluable help rendered in the preparation of this paper by his assistants, P. M. Martin and F. E. Russell, and to A. V. Jones and H. R. Stasney of Albany, Texas, for much of the material on the west-central district. For permission to publish this paper, the writer is indebted to the management of the Continental Oil Company.

INTRODUCTION

During 1938, a considerable advance in development was made in north- and west-central Texas in production from formations deeper than those which had produced most of the oil. The Strawn, in particular, yielded new production over a wide-spread area while the Canyon and the Bend contributed materially toward the activities of the district.

In spite of drastic proration, new discoveries and showings reported in important wildcats kept exploratory work very active throughout the year, which, extending into 1939, culminated in important recent discoveries in Clay and western Archer counties.

In this paper no attempt is made to consider all the new discoveries or extensions. Only those are considered which gave impetus to the development of the district or threw important light on future possibilities.

GENERAL GEOLOGY

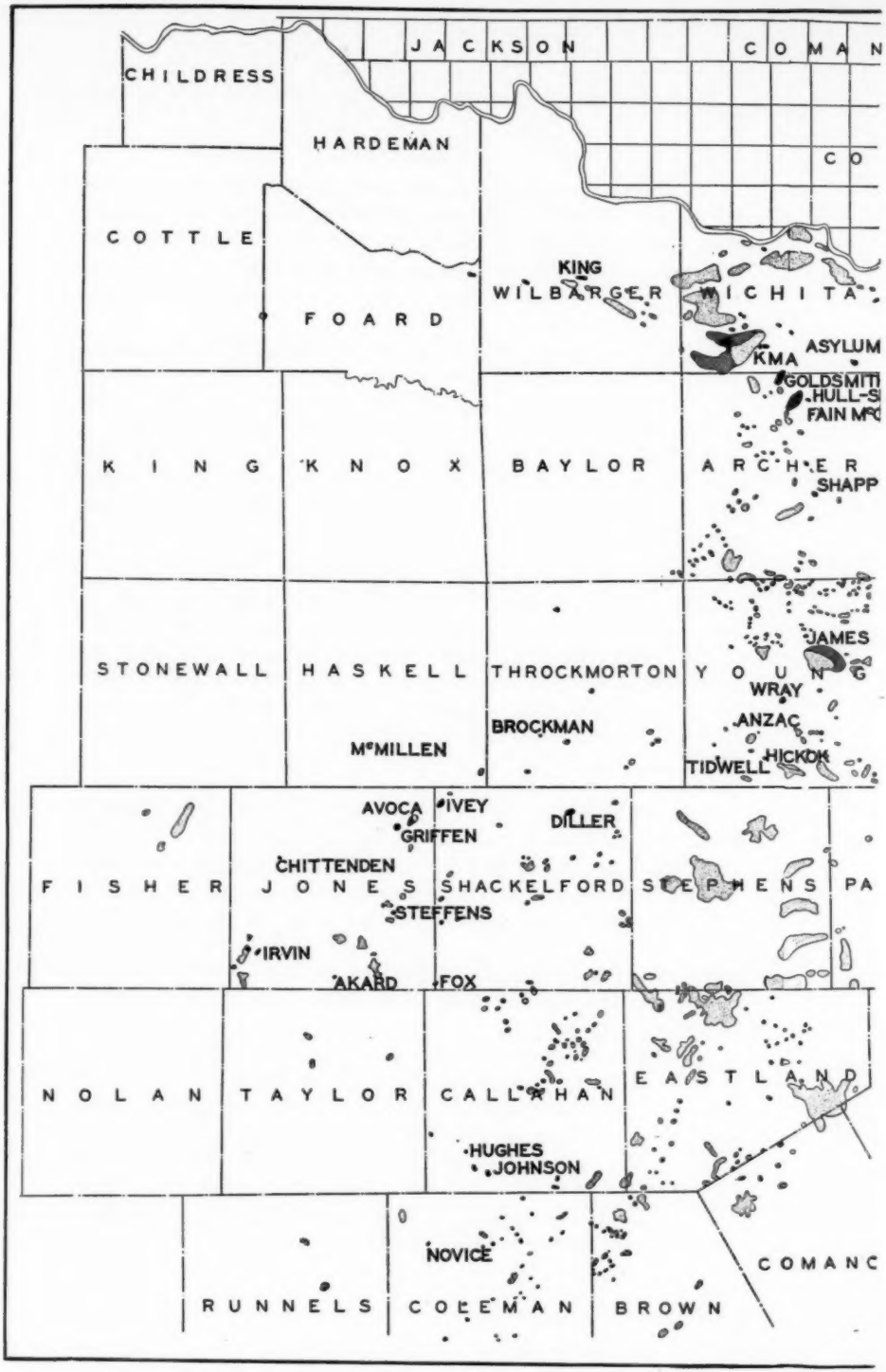
The general geology of North Texas has been described so many times that no attempt will be made here to go into details.[3]

The main structural features consist of the Bend arch which extends from the Central Mineral uplift, roughly through Brown, Eastland, Stephens, Young and Archer counties into Wichita County; the Red River uplift, extending from Petrolia across northern Wichita, Wilbarger, and Foard counties into Cottle County and probably farther west; and the southeastern subsurface extension of the Wichita-Criner Hills uplift, extending into eastern Clay, Montague, and Cooke counties, often referred to as the Muenster arch.

The Bend series and the underlying pre-Pennsylvanian form ridges or anticlines which trend, and over the greater part of the area dip toward the north and northeast; while the Upper Pennsylvanian beds which are draped over them unconformably, dip north and northwest except where they rise to meet the more pronounced trends of the Red River and so-called Muenster arches. The Permian dips in a strong westerly direction.

A secondary feature of tremendous importance in the production of oil is what has come to be known as the South Electra fold of Upper Pennsylvanian beds extending from the town of Electra southeastward into north Archer County, and probably on into Clay County. The K.M.A. field and Hull-Silk pool are located on this trend.

[3] A. W. Weeks, "Developments in North-Central Texas and the Panhandle," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 21, No. 8 (August, 1937), p. 1017.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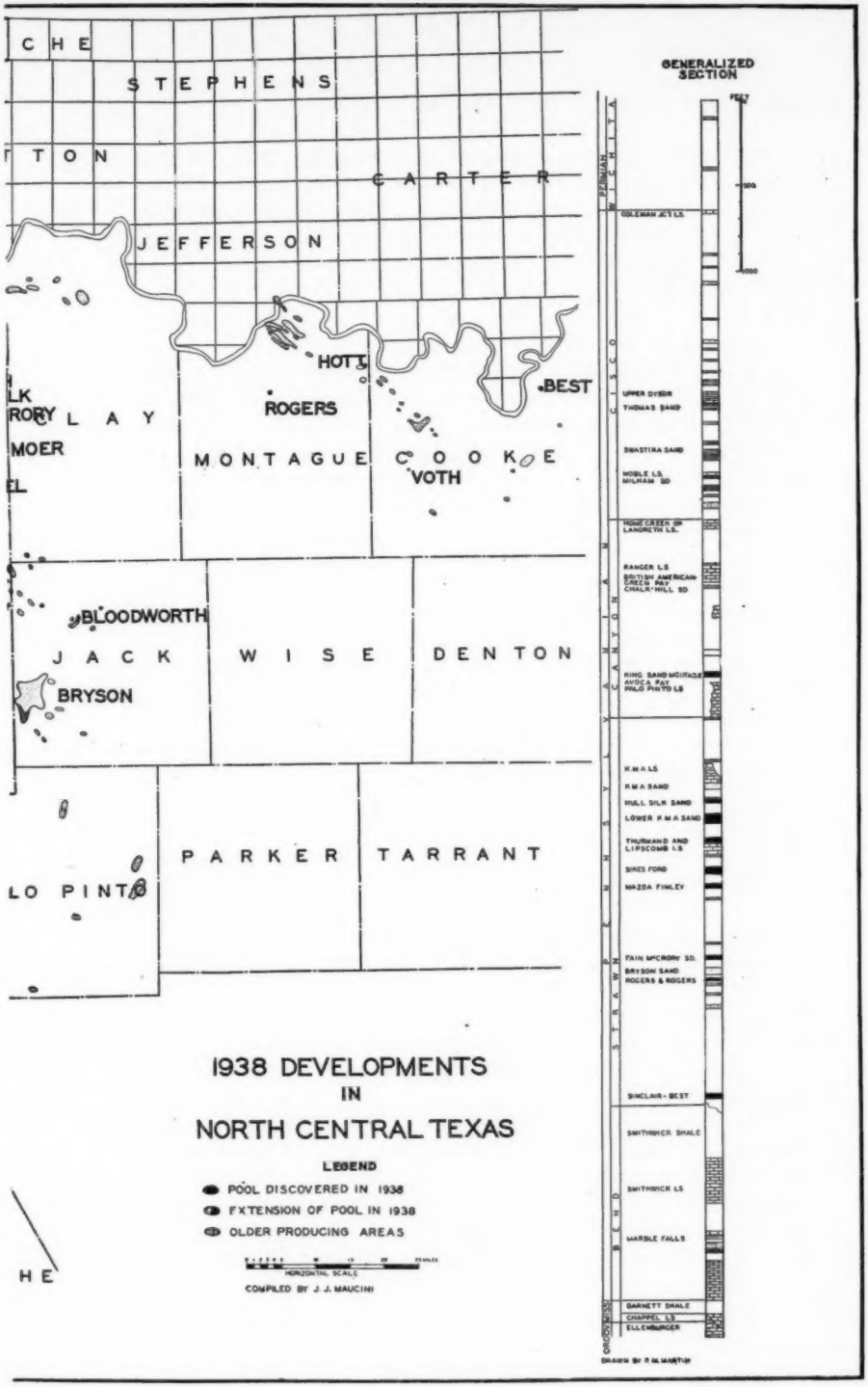
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TARRANT
LO PINTO
GENERALIZED SECTION
PERMIAN
WICHITA
CISCO
UPPER DYSER
THOMAS SAND
SWASTIKA SAND
NOBLE LS.
MILHAM SD
HOME CREEK OR LANDRETH LS.
CANYON
RANGER LS
BRITISH AMERICAN CREEK PAY
CHALK HILL SD
KING SAND MOFFAT
AVOCA PAY
PALO PINTO LS
STRAWN
K M A LS
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HULL SILK SAND
LOWER K M A SAND
THURMAND AND LIPSCOMB LS
SIMS FORD
MAZDA FINLEY
FAIN MCCRORY SD.
BRYSON SAND
ROGERS & ROGERS
SINCLAIR - BEST
BEND
SMITHWICK SHALE
SMITHWICK LS
MARBLE FALLS
ORDOVICIAN
BARNETT SHALE
CHAPPEL LS
ELLENBURGER
1938 DEVELOPMENTS
IN
NORTH CENTRAL TEXAS
LEGEND
POOL DISCOVERED IN 1938
EXTENSION OF POOL IN 1938
OLDER PRODUCING AREAS
HORIZONTAL SCALE
COMPILED BY J. J. MAUCINI

FIG. 1

Incidentally, this cross trending of structural features, one extending in a northerly or northeasterly direction and the other northwest-southeast roughly paralleling the Wichita-Criner Hills trend forms the skeletal structure of the entire area. The Red River arch which is older than either one cuts across both these trends and in its minor details partakes of the nature of both.

PRODUCTIVE SECTION

Formations of practically all the ages represented in the district produce in North Texas. The Ellenburger or the detrital zone immediately overlying the Ellenburger produces in south Young in the McCluskey and South Bend pools, and in Cooke County in the Bulcher, Andress and Voth pools. The only production of commercial importance developed from this zone in 1938 in Cooke County was in the Voth pool approximately two miles south of Muenster. Important showings were developed in the Continental Waggoner 1-E, and the Continental-Petroleum Producers State Asylum No. 1 in Wichita County pointing to future possible commercial production from this zone in this area.

In the west-central area, Ellenburger production of commercial importance is found in Shackelford County in the old Ibex pool and in northwest Eastland County near the Cisco Lake pool. In 1938, some new production of minor importance was developed in southwestern Callahan County, southeast of Oplin.

No production was developed from beds definitely identified as Mississippian prior to 1938. During that year, three wells in separate pools were completed in beds of Mississippian age. The Anzac Graham No. 1 in the A. Hines Survey, Abstract 135, southwest Young was completed in Mississippian limestone from 4,599 to 4,600 feet with an initial output of 126 barrels per day flowing. Hickok and Reynolds Martin No. 2, approximately 3 miles west of South Bend in Young County in the C. Cateran Survey, Abstract 1401, was completed as a 14-barrel flowing well in limestone at 4,431 to 4,436. The Munhall Johnson No. 1, 3 miles south of New Castle, was completed as a 77-barrel producer from limestone at 4,595–4,600 feet. All these are in Young County.

The Jones and Stasney Brockman No. 1 in southwestern Throckmorton County, and Wilcox Portwood No. 1 in southeast Baylor County both reported showings in the Mississippian, which indicates that south Archer, Throckmorton, and southeast Baylor County may have good possibilities for Mississippian production on the more prominent Bend structural trends. In Clay County Gant Edwards No. 1

reported a slight showing of oil in dolomite from 6,000 to 6,200 feet, apparently of Mississippian age.

Although nearly every well drilled sufficiently deep to test beds in the Bend series has reported showings of oil, no production of commercial importance has, as yet, been developed north of Young County. In 1938 the Continental and Petroleum Producers completed a small producer on the State Asylum grounds on the outskirts of the town of Wichita Falls from the Smithwick (Caddo) limestone. In Young County several new pools and extensions of old pools were developed from the same series.

In the west-central district, the Bend has been one of the most important producing formations since 1918. In 1938, however, only a few strikes of minor importance were made. A small northwest extension was developed to the old Crystal Falls pool in Stephens County, and several small wells were brought in in the old Duster area of Comanche County.

The Strawn, Canyon, and Cisco beds contained by far the most important producing zones in the area. In North Texas most of the new strikes were made in beds of Strawn ages. Seven new "pays" were developed in the Strawn. These zones, however, correlate so closely with groups in other areas that some doubt exists as to whether they may be newly found productive beds, or instead, new production in beds already producing in other areas.

The Canyon has not played as important a part in the production of oil as the Strawn, Until rather recently, the Cross Plains pool in Callahan, part of the Overall pool in Coleman County, the Chalk Hill pool in Archer County, and the various pools in northwest Cooke, Wilbarger, and Foard counties, were about all that produced from the Canyon.

In 1938, important discoveries were made in Wichita and Archer counties in the Holliday pool near the town of Holliday and in the King-Castlebury pool in Wilbarger County.

In the west-central district, the Canyon found its most important new developments in the Griffin pool in Jones County and in the McMillan pool in Haskell County.

The beds of Cisco and of Permian age have always been the most important producers in North Texas; and during 1938, a large number of pools were brought in from these formations throughout the entire area. The most important probably was the discovery of production in several new pools in Jones County from the equivalent of the Archer County Swastika pay, notably the Chittenden, Irvin, and as a deeper zone in the old Noodle Creek pool.

DISCOVERIES AND MARKED EXTENSIONS DURING 1938

WICHITA COUNTY

The center of greatest activity in north-central Texas was the K.M.A. field. Prior to 1938, 89 wells had been completed in the field which had proved approximately 10,000 acres. By the end of 1938, 890 wells had been completed and the field extended east, west, and south to include approximately 32,000 acres, adding 4,783,653 barrels of new production to the district's total, and a reserve conservatively estimated at 150,000,000 barrels. Drastic proration has been a very serious deterrent to the development of the field.

The discovery well was completed in April, 1931, by the Deep Oil Development Company on the old Munger Ranch near the town of Kemp City. Although completed for only 109 barrels of oil per day with 250 barrels of water, this well has to date produced nearly 200,000 barrels of oil. Subsequent tests were disappointing and to the beginning of 1935 only five producers had been completed in the field. During 1937 different drilling methods were adopted. Fifty-three wells were drilled during that year with such success that the pool was rapidly extended from the Kemp City area to the Fassett and Tuttle Ranch on the extreme northeast. These wells led to a rush of drilling operations which extended through 1938 with consistent success.

Golding and Cochran extended the south K.M.A. pool approximately 3 miles with the completion of their Preston well No. 1 in Block, 27, H. & T. C. Railway Survey No. 7. This well gauged 108 barrels in 3 hours in the K.M.A. sand at 3,820–68.[4]

Bolin and Whittington Waggoner No. 1 in Section 21, H. & T. C. Railway Survey, Block 7, one mile northwest of Golding & Cochran's Preston No. 1, gauged 123 barrels in 3 hours from a saturated sandy lime between 3,837 and 3,930. Both of these tests were located on a northwest-southeast trend which extends from Kemp City to the Wichita-Wilbarger County line.

The Swanner Parker No. 1 extended the productive area of the K.M.A. field approximately 3 miles east. It was completed for 120 barrels in 24 hours in the K.M.A. sand from 3,999 to 4,014. The structure is a southeast plunging nose off the K.M.A. high.

Near the town of Holliday, Madden and Goldsmith opened a new Canyon pool in the Chalk Hill zone of Archer County, a sand which immediately underlies the Ranger limestone. The sand was encountered in a 4,530-foot test which was plugged back and perforated

[4] Unless otherwise stated all gauges are by Texas Railroad Commission.

through casing at the present producing zone from 2,640–57. The test flowed 66 barrels of oil in 3 hours through 2-inch tubing.

Additional development in the pool has proved disappointing. The majority of wells were completed as pumpers and several made considerable salt water on initial test. There are now fourteen producers and one dry hole.

The structure is a northeast-trending Canyon nose regionally low between the Hull-Silk and the K.M.A. structure.

On the outskirts of Wichita Falls the Continental-Petroleum Producers State Asylum No. 1 in Block 1, Cherokee County School Land, was completed in September, 1938, as the first Smithwick limestone producer in Wichita County. After acidizing from 5,076–5,150 feet the well gave promise of becoming a large producer, but declined rapidly and is now pumping only 50 barrels a day. The structure is a probable 50-foot closure on a northeast-southwest trending Bend high. It was drilled to a total depth of 5,405 feet and topped the Ellenburger at 5,350. Saturation was encountered in a Mississippian dolomite above the Ellenburger and in the upper 30 feet of the Ellenburger. The saturated Ellenburger was shot with 60 quarts with no appreciable increase.

ARCHER COUNTY

The Hull-Silk Wilson (McCrory) No. 1 opened a new Strawn sand pool on March 30, 1938, in the old "Panther" pool, an old Cisco producing area in north Archer County. Further drilling uncovered three additional producing beds in the 600 feet of section immediately below the upper K.M.A. sand; the Thurmond and Lipscomb limestone, the Sikes-Ford, and Mazda-Finley sands. The last, found between 4,293 and 4,305 feet in the Mazda Finley No. 1, 1 mile north of the discovery, promises to be the most important as well as the most widespread "find" in North Texas during recent years. On Railroad Commission test the well gauged 106 barrels in 2 hours and 10 minutes.

Helmerich and Payne drilled their L. F. Wilson No. 2 a short distance southeast of the Hull-Silk discovery well and carried it to 5,270 feet. The Ellenburger was encountered at 5,150 and a showing of oil was reported in it from 5,175–84 feet. Following the completion of the Mazda Finley, this test was plugged back to the same sand and completed with an initial yield of 138 barrels in 3 hours.

As developed at present, the structure of the Hull-Silk pool is a northeast-southwest trending nose on a Strawn limestone equivalent to the Thurmond and Lipscomb producing zone.

The importance of the Finley sand as a possible producer through a widespread area was enhanced by the completion of the Adams Oil

Company's Moer No. 1, 1 mile east of the town of Scotland and 13 miles southeast of the Hull-Silk pool. The test was drilled on a small geophysical structure and gauged 86 barrels of oil in 18 hours. It extends the productive possibilities of the Hull-Silk pool over east Archer and west Clay counties.

CLAY COUNTY

Shallow sands along the axis and on the flanks of the Red River arch in northwest Clay County have proved extremely profitable during the past year. One small prolific pool was discovered and a marked extension to the old shallow producing area developed. The Sussex-Shumake pool in Block 4, Bacon Subdivision, which was discovered in July, 1937, has been gradually extended until it now covers approximately 200 acres.

J. S. Bridwell extended the old Thornberry pool ½ mile southeast. This pool now covers approximately 150 acres. The pay sand may be correlated with the upper Wilmot of Archer County and ranges in depth from 1,000 to 1,100 feet. The wells are completed for 50–250 barrels.

Gant Edwards No. 1 in east-central Clay County was drilled to a total depth of 6,354 feet and penetrated the Ellenburger 100 feet. Slight saturation was encountered in Mississippian dolomite from 6,000–6,200 feet but the well was finally abandoned as a dry hole.

MONTAGUE COUNTY

Since 1924 and prior to 1938, a number of wells were drilled near the town of Nocona on a prominent surface structure, and although good showings were reported at various depths, none was carried below 4,000 feet. In the latter part of 1938, Youngblood and Foree started their Burnett No. 1, 1 mile west of the town, and carried the well to a depth below 4,190 feet. Rogers and Rogers took the well over at that depth and tested a sand between 4,130 and 4,190. The well failed to produce and it was decided to carry it deeper. A second sand was found between 4,645 and 4,654 feet which when tested flowed at the rate of 20 barrels per hour. Although classed as a new Strawn pay horizon for north-central Texas, this sand correlates closely with the Bryson sand of Jack County.

The discovery is located on the southwest flank of a large structure and the productive area may include approximately 2,000 acres.

Seitz, Comegys, and Seitz extended the Hott pool in northeast Montague County ½ mile east with the completion of their King No. 1. This well opened a large area for development in a new Canyon sand

at 1,750 feet. Wells drilled subsequently also extended the Johns (Strawn) or 2,100-foot sand, 1 mile east.

COOKE COUNTY

The Sinclair-Prairie Oil Company opened a pool 5 miles northwest of Callesburg in northeastern Cooke County with the completion of its Best No. 1 in a new productive zone in the lower Strawn at approximately 4,900 feet. To date, a total of four oil wells and one dry hole have been completed for an average of 1,000 barrels per well daily of 36° gravity oil. This field was discovered as the result of geophysical exploration.

Whitfield, Pearson, and Grimes completed their Voth No. 2 (2 miles south of the Muenster Townsite pool in western Cooke County) for approximately 450 barrels per day of 38° gravity oil from the detrital zone overlying the Ellenburger dolomite from 1,785–88 feet. The extent of the productive zone in this area is very indefinite but it is not expected to include more than 40 acres. The productive zone immediately overlies a sharp ridge of Ellenburger dolomite which is unconformably overlain by upper Strawn sandstones and shales and limestone.

WILBARGER COUNTY

King Oil Company Castlebury No. 1 discovery in Section 68, H. & T. C. Railway Survey, Block 14, was brought in during October, 1937, but the pool was developed largely in 1938. This well had an initial production of 288 barrels in 24 hours. There are six producers in the pool at present. Three are producing from the upper Dyson sand, two from the Milham sands (Cisco), and one from the Landreth limestone (Canyon). The structure is a northwest-southeast trending nose off the north flank of the south Vernon pool. The pool covers approximately 140 acres with two dry holes on the west and one a location east of King Oil Castlebury No. 2.

King-Phillips Waggoner pool in Section 63, H. & T. C. Railway Survey, Block 14, approximately 1 mile east of the King Castlebury pool has two producers and a drilling well at present. The discovery well was brought in May 11, 1938, and had an initial production of 176 barrels in 24 hours from the Milham sand.

YOUNG COUNTY

Renewed activity during 1938 in the James pool, 6 miles north of Graham, has extended the producing area from 3,000 to approximately 6,000 acres. Production in this pool is derived from the Smithwick (upper Bend) gray limestone.

The Sims pool, 3 miles southwest of Graham, was extended 2 miles east by the Homestead Oil and Gas Knight No. 1 which was completed for 1,233 barrels per day from Smithwick limestone at 3,760–75 feet. This well revived interest in this area and has opened approximately 1,500 acres for drilling. The wells range in size from 50 to 2,400 barrels per day. Some wells produce naturally; others are treated with 10,000 to 20,000 gallons of acid.

R. V. Tidwell Ivey No. 1 was completed as a 52-barrel well in the Smithwick limestone from 3,737–50 feet. This well opens a new Bend pool, approximately 4 miles northwest of the Connell pool in southwest Young County. The productive area will probably include 500 acres.

Anzac Oil Company Graham No. 1, 4 miles northeast of Murray in southwest Young County, was completed for 126 barrels natural from Mississippian (Boone) limestone between 4,599 and 4,600 feet. This is the second commercial pre-Pennsylvanian well completed in Young County. The first, the Panhandle McCluskey No. 7 in the South Bend pool, was completed for 3,500 barrels per day in 1927 from the upper Ellenburger limestone, and is estimated to have produced in excess of 1 million barrels of oil.

The Wray pool, 3 miles south of New Castle, in central Young County, was discovered in 1938 by the Munhall *et al.* Johnson No. 1 which was completed in the Mississippian limestone (Boone) from 4,595 to 4,600 feet, for an initial yield of 77 barrels per day. Two additional wells have been completed in the pool: Brazos Young Faye Wray No. 1 in the Oölitic member of the Marble Falls for 659 barrels per day natural, and Pitzer and West Bullock No. 1 for 700 barrels per day from Marble Falls (Ranger) sand between 4,320 and 4,330 feet. This pool is expected to cover approximately 200 acres.

HASKELL COUNTY

McMillen Pardue No. 1, 8 miles south of Haskell, opened a new pool in an upper Canyon limestone, approximately equivalent to the Ranger limestone, with an initial production of 126 barrels of 38° gravity oil after acid treatment from 2,635 to 2,654 feet.

Production occurs on top of a sharp northeast-southwest trending structure defined by core drilling. The productive area is expected to be confined to not more than 40 acres with a recovery of 2,000 barrels per acre. This is the second pool in Haskell County, the other being the Moody pool, 13 miles southeast, which is producing from the King sand in the Cisco at approximately 1,750 feet.

JONES COUNTY

Two new pools were discovered in western Jones County in the Swastika sand and new, deeper production was found in this horizon

in the Noodle Creek field. In eastern Jones County the Avoca pool, producing from a lower Canyon limestone (Avoca pay) was extensively developed, a new pool discovered in this same zone, and three new pools were discovered in shallower Cisco zones.

Avoca pool.—The Avoca pool, 3 miles northeast of Avoca, was discovered in the latter part of 1937, and at the end of the year only 7 wells had been completed. During 1938, 35 wells were drilled and production extended through approximately 800 acres. The field has been defined on the south, east, and west.

The producing zone is a very fossiliferous, porous limestone in the lower part of the Canyon at approximately 3,250 feet. The thickness varies from 10 feet in the edge wells to 30 feet or more in the middle of the field. Initial yields vary from a few hundred barrels after acid treatment in the wells located on the edges of the pool, to 3,000 barrels or more of natural yield in those in the middle part.

The oil is 42°–43° gravity. The allowable at present is 49 barrels per day.

Companies operating in the area estimate from their core analysis that this field will produce from 10,000 to 12,000 barrels per acre.

Griffin pool.—The Griffin pool, centering ½ mile east of the town of Avoca, was discovered in the latter part of 1938. It is producing from the Avoca (lower Canyon) limestone at 3,250 feet. The thickness of the pay is from 10 to 25 feet or more. Initial yields vary from a few hundred to 3,000 barrels of oil per day of 42°–43° gravity oil. At present the allowable is 100 barrels per day.

Steffens pool.—The Steffens pool in east-central Jones County is 7 miles northeast of Hawley and 1 mile northeast of the Lewis pool.

It is producing from the Bluff Creek sand at 1,900 feet and the Flippen limestone at 1,950 feet. Wells are completed for 100–500 barrels of 37°–39° gravity oil from 5 to 26 feet of sand.

Fox and Rudd pool.—The Fox and Rudd pool in the extreme southeastern part of Jones County on the Jones-Shackleford County line is producing from the lower Tannehill sand at approximately 1,700 feet. Wells are completed for approximately 200 barrels per day of 37° gravity oil from 10 to 12 feet of sand.

Akard pool.—The Akard pool, approximately 4 miles southwest of Hawley near the middle of the south line of Jones County, is producing from 12 feet of Cook sand at 2,150 feet. This pool is located on a sharp structure and has been defined on the southwest side. One well has been completed for approximately 200 barrels per day of 39° gravity oil.

Irvin pool.—The Irvin pool in southwest Jones County is approximately 1½ miles east of the north end of the Noodle Creek pool. The

discovery well in this field (Humble Oil and Refining Company Irvin No. 1) was completed for 200 barrels per day in the lower Tennehill zone at 2,550 feet, which in this area is a sandy limestone. The southwest offset to this well was drilled to the Swastika sand at 2,900 feet and completed for an initial production of 1,000 barrels per day of 40° gravity oil from 16 feet of sand.

Five wells have been completed in the Swastika zone for an average initial yield of 1,000 barrels per day.

In addition to the Swastika sand at 2,900 feet and lower Tannehill sand at 2,550, saturation has been found in the Noodle Creek zone at 2,400 feet, but no wells have been stopped in this zone.

Noodle Creek.—One well on the Humble Bickley lease on the north end of Noodle Creek pool was deepened to the Swastika sand at 3,000 feet for an initial production of 750 barrels per day of 40° gravity oil.

Chittenden pool.—The Chittenden pool, 6½ miles northwest of Anson in west-central Jones County, is producing from the Swastika sand at 3,000 feet. Two wells have been completed for approximately 150 barrels of 39° gravity oil from 12 feet of sand.

Lewis pool.—The Lewis pool in east-central Jones County was extended ½ mile east in the Bluff Creek sand at 1,900 feet. Wells in this extension average 700 barrels per day from 10 to 20 feet of sand.

SHACKELFORD COUNTY

Ivey pool.—The Ivey pool in the extreme northwest part of Shackelford County was originally opened for production from a limestone at 1,950 feet in the latter part of 1937. In January, 1938, one of the wells was carried down to the Avoca lower Canyon pay at 3,200 feet. It and subsequent wells were completed for 600 to 700 barrels per day of 42° gravity crude from 10 to 12 feet of saturated limestone pay.

Lee and Keys pool.—The Lee and Keys pool on the Diller Ranch, 3 miles south of Fort Griffin, although discovered in the latter part of 1937, was developed in 1938. The wells produce from 5 to 25 barrels per day from 5 to 10 feet of Tannehill sand at 520 feet.

The major part of the drilling in Shackelford County has been the development and minor extensions of older pools in the western part where the sands are all Cisco in age and range in depth from 1,500 to 2,100 feet in depth.

CALLAHAN COUNTY

No important new discoveries were made in Callahan County in 1938. Drilling was mostly confined to minor extensions of the shallow producing Cisco fields in the Putnam Baird and Belle Plains area where production is found in sands from 300 to 1,500 feet.

Several wells were drilled to the Ellenburger limestone in the Oplin area in the southwest part of the county in an attempt to extend the pre-Pennsylvanian pay at approximately 4,350 feet. First Ellenburger production in this area was discovered in 1927 by the Empire Oil and Gas Company Johnson No. 1 with an initial production of 716 barrels of oil from 4,087 to 4,140 feet. This well produced 20,000–30,000 barrels of oil before it stopped producing. In 1938, Woodley Petroleum Flores No. 1, 2½ miles northeast, came in for an initial production of 50 barrels per day from pre-Pennsylvanian limestone from 4,292 to 4,333. Another small Ellenburger producing area was discovered by Hughes *et al.* in their Poindexter No. 1, 4½ miles northwest of the Johnson well. These discoveries led to the drilling of five wildcat Ellenburger tests which were dry and five wells in the vicinity of the new discoveries resulting in one gas well, one small oil well and three dry holes.

COLEMAN COUNTY

A small pool was opened in northwest Coleman County 1 mile west of Novice by the Cooper *et al.* Stockard No. 1, which was completed for 46 barrels per day in Strawn sand from 3,646 to 3,657 feet. This sand is the same as that producing in the Goldsboro pool, 4 miles northwest. The productive area is not expected to exceed 160 acres.

TAYLOR COUNTY

No new pools were developed in Taylor County during 1938. A minor northeastward extension was made to the View pool in the north-central part of the county in the regular limestone pay at 2,390 feet (approximately Saddle Creek), the wells from which yielded as much as 1,000 barrels per day.

The Dunn and McAlister pool, 7 miles southwest of Abilene, was extended ¼ mile westward. The wells in this area are small and in the same producing zone as the View pool.

PRODUCTION AND DRILLING

In spite of the fact that drilling operations as a whole in north-central Texas in 1938 were about the same as those in 1937, nearly double the number of new pools and important extensions to old pools resulted. In north-central Texas 2,348 wells were drilled in 1938 as against 2,254 in 1937.

Of the former 250 were wildcats resulting in 16 new pools, 31 important extensions to old pools or new sands in pools already established, and 203 were dry. The total number of wildcats drilled in 1937 were not materially less than of those drilled in 1938. Approximately 230 were drilled, of which 24 resulted in new pools or extensions, 4 in gas wells, and 202 were dry.

TABLE I

WELLS DRILLED IN NORTH-CENTRAL TEXAS, 1938

County	*Producers*	*Dry*	*Total*
Archer	119	100	219
Baylor	0	8	8
Clay	108	64	172
Cooke	107	40	147
Denton	1	9	10
Foard	1	4	5
Grayson	1	4	5
Haskell	5	6	11
Knox	0	3	3
Montague	50	18	68
Throckmorton	0	16	16
Wichita	872	179	1,051
Wilbarger	41	25	66
Wise	0	1	1
Young	160	152	312
Jack	150	104	254
Total 1938	1,615	733	2,348
Total 1937	1,250	1,004	2,254

WELLS DRILLED IN WEST-CENTRAL TEXAS, 1938

County	*Producers*	*Dry*	*Total*
Brown	32	30	62
Callahan	5	37	42
Coleman	10	24	34
Comanche	5	7	12
Eastland	9	12	21
Erath	0	3	3
Fisher	23	18	41
Jones	179	19	198
Palo Pinto	5	19	24
Shackelford	79	71	150
Stephens	7	5	12
Taylor	3	11	14
Total 1938	357	256	613
Total 1937	385	302	687

In the four counties in west-central Texas where wildcatting was most active, Jones, Shackelford, Callahan and Taylor, 88 wildcats were drilled in 1938, resulting in 10 new pools, 5 important extensions, and 1 gas well. In all of west-central Texas in 1937 approximately the same number of wildcats were drilled, resulting in only 6 new pools and extensions.

The greater success of wildcatting operations in 1938 over those drilled in 1937 was by no means accidental. The excellent performance of some of the wells completed in the K.M.A. field and in Jones County late in 1937 resulted in a larger use of geophysical methods of exploration by both independent operators and major companies, and for the most part increases in personnel in the geological departments of those already represented in the areas with consequent stronger emphasis on geological work, especially subsurface.

Because of drastic proration, however, especially in north-central Texas, production can hardly be said to have maintained its own. Three hundred nine thousand, five hundred ninety nine (309,599) barrels less were produced in 1938 than in 1937. In the northern district 28,763,690 barrels were produced in 1938, as against 28,028,226 in 1937, while in the southern area only 9,333,087 barrels were produced as compared with 10,378,150 barrels.

TABLE II

OIL PRODUCTION IN NORTH-CENTRAL TEXAS DISTRICT

County	*Production Jan. 1, 1936 to Jan. 1, 1937*	*Production Jan. 1, 1938 to Jan. 1, 1939*	*Total to Jan. 1, 1939*
Archer	4,651,140	3,854,862	112,684,864
Baylor	641,497	417,621	3,971,123
Clay	238,382	543,214	7,497,619
Cooke	2,663,753	1,741,877	15,201,078
Foard	266,198	207,639	1,487,312
Haskell	5,470	32,606	130,804
Jack	3,088,712	2,516,004	12,283,019
Montague	2,219,117	1,188,192	28,288,093
Throckmorton	148,522	116,029	3,207,193
Wichita	6,610,590	10,224,872	311,940,545
Wilbarger	3,193,284	3,058,022	65,318,472
Young	4,301,561	4,162,752	61,199,425
	28,028,226	28,763,690	623,209,547

OIL PRODUCTION IN WEST-CENTRAL DISTRICT

County	*Production Jan. 1, 1936 to Jan. 1, 1937*	*Production Jan. 1, 1938 to Jan. 1, 1939*	*Total to Jan. 1, 1939*
Brown	627,541	584,460	29,430,117
Callahan	534,147	453,914	13,572,409
Coleman	381,695	353,981	9,707,437
Eastland	874,608	865,524	73,747,984
Desdemona	206,598	199,331	23,596,997
Fisher	1,197,204	1,252,632	10,339,304
Jones	2,310,352	2,025,503	12,384,790
Palo Pinto	114,661	116,478	5,028,980
Runnels	48,905	35,130	907,156
Shackelford	2,556,261	2,152,611	35,853,865
Stephens	1,500,720	1,266,637	131,624,570
Taylor	26,458	26,886	285,587
Total	10,378,150	9,333,087	346,479,196

The slight increase in the former district of only 735,464 takes on added significance when the fact is considered that the K.M.A. field alone produced 4,783,653 barrels of new oil in 1938. The combination of legislative and pipe-line proration, and of the Saturday and Sunday shut-down were very effective in preventing material increase in production for the year, but they apparently had little influence in restricting the activity in wildcatting.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE, 1939), PP. 860-870, 1 FIG.

DEVELOPMENTS IN SOUTH TEXAS, 1938–1939[1]

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ABSTRACT

There were 40 new fields discovered in South Texas during the past year. In addition 58 new sands in the older fields were proved for production. This record is exceeded only by the year 1937 and exceeds the records of other years both in the number of discoveries and in probable additions to reserves.

The outstanding feature has been the development of important production from the Frio-Vicksburg along the updip side of the coastal province. This sand group has furnished some production in the past but discoveries during 1938 place it among the major oil-producing zones in the district. Of the discoveries, 8 fields and 27 sands were from this zone. Probably the more important of the fields are Alice in Jim Wells County, Kelsey in Jim Hogg County and Sun in Starr County.

The downdip side of the coastal province again furnished substantial additions to reserves with 9 new fields, numerous extensions and additional sands. Of these new fields Cordele, West, and Francitas in Jackson County; and La Rosa and Melon Creek in Refugio County offer the most promise; and, as a group, are probably the year's greatest contribution to South Texas reserves.

The Jackson trend continued to lead in the number of discoveries with 16 new fields. Excepting Fitzsimmons in Duval County, most of these may be relatively small.

Likewise the 6 Cretaceous fields opened in the fault line may have small recoveries.

Following the precedent set by the previous annual reports to this convention covering activities in South Texas, this report covers the twelve months' period ended March 1, 1939.

For convenience in this discussion the producing zones will be grouped into 6 generalized stratigraphic divisions, in sequence from oldest to youngest. Likewise, some of the prospective zones that are often the objectives in wildcat drilling will be included in this sequence. These subdivisions are: (1) the Ordovician and Pennsylvanian of the Edwards Plateau; (2) the Cretaceous in the fault line; (3) the Wilcox, Carrizo, Queen City and Sparta in the Lower Eocene trend; (4) the Yegua and Jackson of the Upper Eocene; (5) the Frio-Vicksburg of basal Oligocene age; and (6) the Upper Oligocene and Lower Miocene of the coastal area, including the *Marginulina*-Frio, Catahoula, and Oakville.

In a wide belt along the northwest side of the coastal province is found a series of sands, probably both Frio and Vicksburg in age, that has not been satisfactorily subdivided. This series seems to be sufficiently different from the downdip Frio to merit a subdivision, and the name Frio-Vicksburg has come into fairly common use as a means of designating it.

The younger formations, successively, are the objectives, from the Edwards Plateau southeastward to the coast. The various Cre-

[1] Read before the Association at the Oklahoma City meeting, March 23, 1939.

[2] Stanolind Oil and Gas Company.

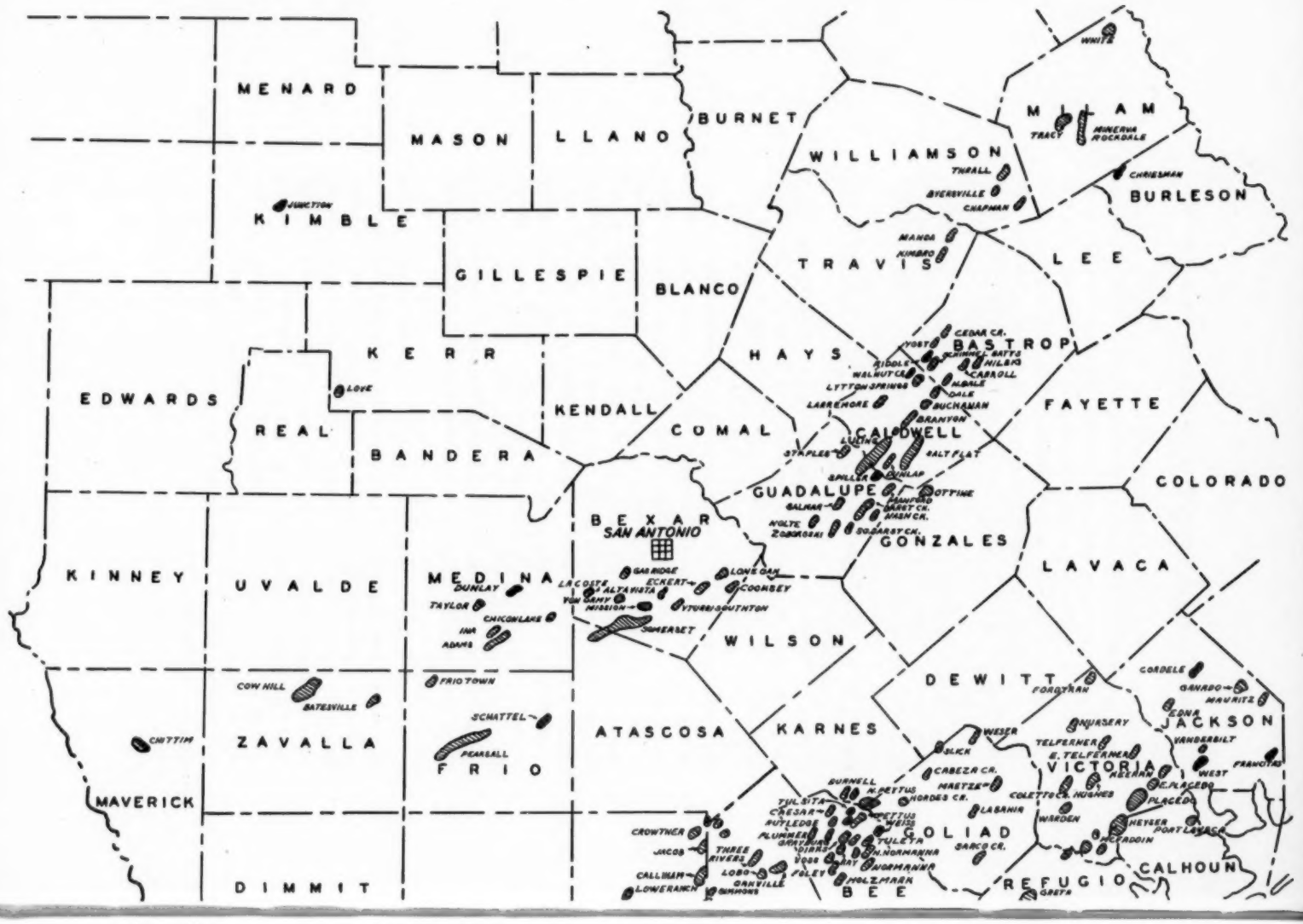
taceous and Tertiary producing zones extend across South Texas in trends or belts, roughly parallel with the coast line. Beds of Cretaceous age are on the surface at San Antonio and the surface exposures of all the younger beds are between San Antonio and the coast, a distance of only 140 miles. Of course, most of the formations thin toward the outcrop and many individual zones present in the subsurface do not reach the surface due to lensing or overlap.

During the past year 40 fields were discovered in South Texas. The geographic positions of these are shown in Figure 1. In addition, 58 new sands were proved for production in older fields, which number includes sands, other than the discovery sand, in the new multiple-sand fields. This record is exceeded only by the year 1937–1938, and exceeds the records of other years both in the number of discoveries and in probable additions to reserves.

One of the new fields was in the Edwards Plateau, 6 were in the fault line, 16 in the Jackson-Yegua trend, 8 in the Frio-Vicksburg trend, and 9 in the coastal area. Further subdivided, 2 of the 6 discovery wells in the fault line were completed in the Austin chalk, 2 in serpentine, and 1 each in the Edwards and Taylor. Of the 16 discovery wells in the Jackson-Yegua trend, 12 were completed in Jackson sands and 4 in the Cockfield or Pettus sand zone. The wells in the 8 new pools in the Frio-Vicksburg are all considered as being from the same general zone. Of the 9 fields opened in the coastal area, 5 produce from sands in the Frio, 3 from sands in the *Marginulina* zone and 1 from a sand in the basal portion of the Oakville.

A geologic subdivision of the 58 new sands in older fields places 1 in the Yegua, 6 in the Jackson, 29 in the Frio-Vicksburg, 19 in the Frio, 1 in the *Marginulina* zone and 2 in the Catahoula. As these figures correctly suggest, most of the multiple sand pools in South Texas are producing from sands in the Frio, the Frio-Vicksburg, or the Jackson.

A comparison of these discoveries with those of other years shows that the outstanding feature has been the development of important production from the Frio-Vicksburg. This sand group has furnished some production in the past but discoveries during the last 12 months place it among the major oil-producing zones in this district. The deep coastal area has duplicated its favorable records by again furnishing substantial additions to reserves, with the *Marginulina*-Frio zone holding its leading position as probably the greatest source of oil in South Texas. The Jackson-Yegua trend continued to lead in the number of new fields but most of them may prove to be relatively small and the total of their ultimate recoveries will probably be far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BASTROP
EDWARDS
REAL
KENDALL
COMAL
CALDWELL
FAYETTE
BANDERA
GUADALUPE
COLORADO
BEXAR
SAN ANTONIO
GONZALES
KINNEY
UVALDE
MEDINA
LAVACA
WILSON
DEWITT
ZAVALLA
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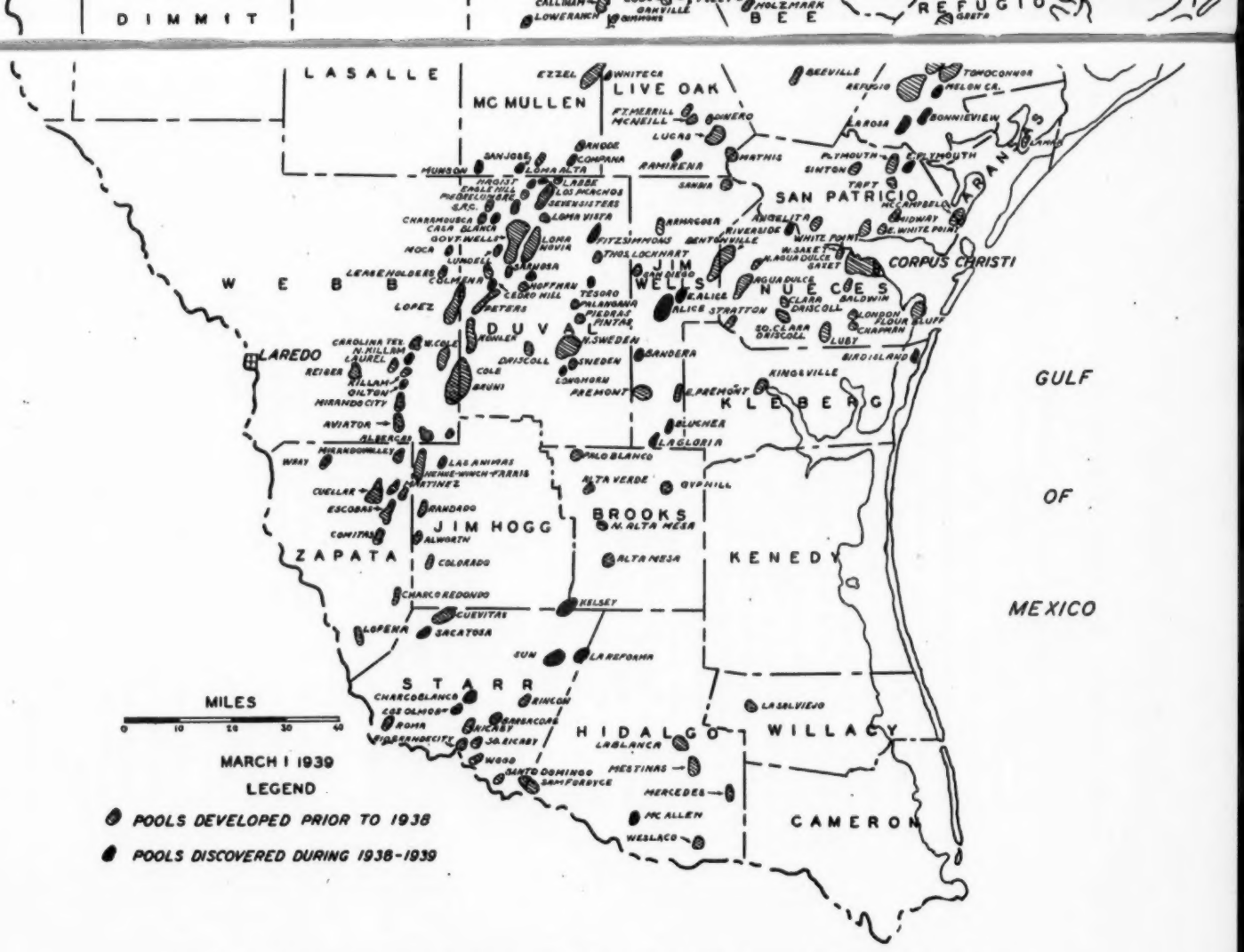

FIG. 1.—Map of South Texas showing pools developed prior to 1938 and pools discovered during 1938 and part of 1939.

less than the total recoveries from the smaller number of coastal fields. Likewise, the 6 Cretaceous fields opened in the fault line may have small recoveries.

Nearly all of the discoveries in the coastal area and in the Frio-Vicksburg trend are credited to geological work followed by geophysical exploration. In most instances, reflection-seismograph work is to be given the direct credit in the selection of the locations of the discovery wells. In some locations, torsion balance, gravity meter, or magnetometer, was used in preliminary exploration.

On the contrary, very few of the discoveries in the Jackson-Yegua trend or in the fault line may be credited to geophysical exploration. Most of these discovery locations are attributed to subsurface geology and trend drilling. It is generally conceded that seismograph work has not proved very satisfactory in many parts of the Jackson-Yegua trend and the fault line, partly because of the difficulties presented by the surface formations and partly because of the low structural relief, and the small size and the faulted condition of many of the structures. Also the stratigraphic traps in many of the Jackson fields seem to present an insurmountable problem to the ordinary geophysical methods.

EDWARDS PLATEAU

As usual, there was very little drilling activity in the Edwards Plateau during the year. The Plateau Oil Company opened the Junction field in Kimble County with 2 wells producing small quantities of oil and gas, one from the Pennsylvanian at 1,400 feet and the other from the Ellenburger at 1,800 feet. Nothing more than minor production from a few wells has ever been developed in that part of the Edwards Plateau included within South Texas.

FAULT LINE

Most of the discoveries made in the Cretaceous during 1937 have thus far proved to be very small and approximately one-half of them are still 1-well pools with 1 or more offset failures. The same is true of the 1938 discoveries, none of which has yet been developed into a pool of appreciable size.

The amount of drilling activity in the fault line has decreased materially from that of the past several years. The reasons for this decrease are probably the disappointing results in the new producing areas and the approach of the desired density of drilling in the older fields.

New Cretaceous pools are Chriesman in Burleson County, producing from the Edwards; Schattel in Frio County and Spiller in

Guadalupe County from Austin chalk; Walnut Creek in Caldwell County and Dunlay in Medina County from serpentine; and Riddle in Bastrop County from the "Dale lime," which is a local formation probably basal Taylor in age.

The discovery and only producing well in Schattel proved to be very small and it was plugged and abandoned after several dry holes were drilled in the locality. With one exception, none of the other discoveries seems to merit further discussion, because they are more or less typical of the smaller types of fault-line field.

Chriesman.—The mapping of a fault structure on the surface led to drilling in the Chriesman area. The first two tests were failures and the third test, drilled by the Red Bank Oil Company, was completed with an initial production of 180 barrels daily of 40° gravity oil, pumping, from the Edwards limestone at 6,167–6,173 feet. No additional wells have been drilled. This discovery is of particular significance because it may revive interest in a wide belt, downdip from the usual producing trend. Heretofore, commercial production from the Edwards has been limited to a maximum depth of approximately 2,700 feet.

LOWER EOCENE

Only minor production has ever been found in South Texas in the Lower Eocene group. Nearly all of this has been from the Queen City in the Lopeno field, Zapata County, which yielded gas. Comparatively few wells have penetrated these formations and little subsurface information is available. However, recent discoveries in the Wilcox and Sparta in Louisiana and eastern Texas have placed these zones in the spotlight as objectives in wildcat drilling; therefore additional development along this trend is to be expected. The year 1938 added no new production from these zones.

JACKSON-YEGUA TREND

A continuation of the relatively active wildcat drilling campaign along the Jackson-Yegua trend resulted in the discovery of 16 fields. New pools in the Cockfield or Pettus zone are Tulsita in Bee County, Ramirena in Live Oak County, and Fitzsimmons and Tesoro in Duval County. All of the other new fields are producing from sands in the Jackson. They are White Creek in Live Oak County; Campana, Munson, and San Jose in McMullen County; Casa Blanca, Cedro Hill, Longhorn, and Los Picachos in Duval County; Bandera in Jim Wells County; North Killam in Webb County; and Charco Blanco and Sacatosa in Starr County.

Although the number of Jackson and Cockfield discoveries in

1938 is nearly as large as the number in 1937, the quality of the new fields, as a whole, seems to be inferior. Further development will be necessary before many of the new pools can be correctly evaluated; however, present information makes it appear that many of them will be of minor importance and that none of them will compare favorably in size with the larger fields in this trend.

Fitzsimmons.—The opening of the prolific North Sweden or Benavides field in eastern Duval County in 1937 resulted in an active play for deeper Jackson and Cockfield production, downdip from the older producing areas. This deeper play led to the discovery of the Fitzsimmons field in northeastern Duval County by Jack Porter *et al.* The principal producing sand averages 4,300 feet in depth and is the Pettus member of the Cockfield. A shallow Jackson sand at 3,600 feet in the Hockley zone furnishes minor production in one well. Present development totals 50 oil wells on 10-acre spacing and 4 failures. The gravity of the oil is 47° and the initial production of the wells varies from 100 barrels to more than 200 barrels daily, flowing through $\frac{1}{8}$ to $\frac{1}{4}$ inch chokes. Accumulation is due to structural closure against a strike fault of about 140 feet displacement, downthrown to the northwest, the field being elongated in a northeasterly direction.

Casa Blanca and Cedro Hill.—A limited program of shallow wildcat drilling by the Magnolia Petroleum Company on its extensive leaseholdings in northwestern Duval County resulted in the opening of the Casa Blanca and Cedro Hill fields. Production in both fields is from the Cole sand series near the top of the Jackson.

Casa Blanca now has 36 oil wells, 3 gas wells, and 6 dry holes on 10-acre spacing. The producing sand averages 1,200 feet in depth and the initial production of the wells ranges from 50 to more than 100 barrels daily, some pumping and others flowing. The oil is the ordinary Mirando type of crude of 20° gravity. Accumulation is probably due to a combination of low relief structure, faulting, and stratigraphic trap, similar to most of the Jackson fields.

The Magnolia's discovery well in Cedro Hill was completed in November, 1938, at 1,441–1,451 feet, with an initial production of 30 barrels per day, pumping. No additional wells have been drilled.

FRIO-VICKSBURG TREND

Developments in the Frio-Vicksburg trend during the year have elevated this group to a place among the major oil-producing zones in South Texas. The new fields are Alice, East Alice, La Gloria, and Blucher in Jim Wells County; Kelsey in Jim Hogg County; La Reforma and Sun in Starr County; and McAllen in Hidalgo County.

Alice.—This field, located in central Jim Wells County, was discovered in April, 1938, by H. H. Howell. There are 62 oil wells in the field, of which 6 are twins, 2 gas wells, and 10 dry holes. The spacing program is 20 acres. The gravity of the oil varies from 38° to 43° and the several producing zones range from 4,500 to 5,500 feet in depth. Good ultimate recoveries are anticipated from these high-pressure sands. The producing sands all lens out to the west, forming stratigraphic traps that are associated with an undetermined amount of structural folding and possibly faulting.

East Alice.—East Alice appears to be a separate field centering 3 miles northeast of the Alice field. Most of the development has taken place within the last 3 months and now totals 15 oil wells and 1 gas well. Production is from several sands in the same general zone as the Alice pays.

Blucher and La Gloria.—The opening of the East Premont field in 1937 aroused intense interest in the southern part of Jim Wells County. Several miles southwest of East Premont, the Shell Petroleum Corporation opened the Blucher field with a high-pressure gas and distillate well at 7,555–7,560 feet. Still farther southwest the Magnolia Petroleum Company is nearing completion of its discovery well at La Gloria. Drill-stem tests have indicated large gas and distillate production from a number of sands between 5,200 and 6,100 feet. Both Blucher and La Gloria are reflection-seismic prospects.

Kelsey.—In August, 1938, the Humble Oil and Refining Company completed the discovery well in the Kelsey field in Jim Hogg County at 4,740–4,748 feet with an initial production of 94 barrels daily, flowing through ⅛-inch choke, gravity 43°. Subsequent development includes 6 oil wells and 3 dry holes. Accumulation is probably due to anticlinal structure.

Sun.—Both geophysical exploration and core drilling preceded the Sun Oil Company's discovery of the Sun field in Starr County. The discovery well was completed at 4,853–4,856 feet with an initial production of 182 barrels of 42° gravity oil daily, flowing through a small choke. There are now 6 oil wells and 1 gas well in the field, scattered through an area 2 miles long and 1 mile wide. Two outlying dry holes have been drilled. Production is from 3 or more different zones between 4,600 and 5,100 feet and the pay sands seem to be erratic and lenticular in nature.

COASTAL AREA

The new Frio fields in the coastal area are Francitas in Jackson County; Bonnieview, La Rosa, and Melon Creek in Refugio County; and Riverside in Nueces County. The *Marginulina* or Greta zone was

found productive in the West field in Jackson County, the East Plymouth field in San Patricio County, and the Bird Island field in Kleberg County. The other new coastal field is Cordele in Jackson County, which is producing from a sand thought to be basal Oakville in age. These fields, as a group, are probably the year's greatest contribution to South Texas reserves.

Cordele.—The Cordele field in northern Jackson County was opened by H. J. Porter on completion of a well at 2,652–2,660 feet with an initial production of 125 barrels daily, flowing through a small choke. There are now 15 oil wells, 2 gas wells, and 2 dry holes in the area. Structural closure against a fault with more than 200 feet of throw, downthrown to the northwest, accounts for the accumulation. The Oakville, which produces here, has furnished some gas production in South Texas, but there has been very little oil produced from it.

West.—Magnolia Petroleum Company completed the discovery well in this field at 5,080–5,086 feet. The initial production was 132 barrels per day of 25° gravity oil through $\frac{8}{64}$-inch choke, from the upper part of the *Marginulina* or Greta sand zone. There are now 6 oil wells on this seismic prospect. The accumulation appears to be near the top of a large anticlinal fold.

La Rosa.—For many years it has been generally known that the La Rosa area was structurally high and several tests have been drilled in the general area. Coronado Exploration Company selected the discovery location as a result of seismic work. The field now has 22 oil wells on 20-acre spacing and the producing area is not yet defined. Oil production is from 3 zones in the Frio at 5,900, 6,100 and 6,300 feet. The oil is 40° gravity and the initial production of the wells is over 100 barrels daily on small choke.

Melon Creek.—Copano Oil Company opened the Melon Creek field in Refugio County in February, 1939. The discovery well was completed in Frio sand at 5,855–5,875 feet with an initial production of 240 barrels daily through $\frac{5}{32}$-inch choke, gravity 38°. This new field is a short distance southwest of and along strike with the Tomoconnor Field which is considered the greatest oil reserve and most prolific field in South Texas. The pay sand in Melon Creek appears to correlate with the thickest pay zone in Tomoconnor.

Bird Island.—The Bird Island field is located in Laguna Madre $1\frac{1}{2}$ miles from the mainland. The Pure Oil Company worked this submerged area with seismograph and later drilled and completed a large gas well spraying some distillate. The production is from the *Marginulina* zone at 7,210–7,278 feet. This field is farther downdip than any other producing area in South Texas.

OLDER FIELDS

The outstanding new sands and extensions in older fields were at McCampbell in Aransas County; Samfordyce in Hidalgo County; Clara Driscoll and West Saxet in Nueces County; and East White Point in San Patricio County. A recent extension 1 mile south to McCampbell resulted in an active drilling campaign. West Saxet and East White Point, discovered late in 1937, have developed into excellent Frio sand pools of small size.

DEEPER DRILLING

In the Agua Dulce field, Nueces County, the Union Producing Company drilled its Minnie Brown No. 1 to a total depth of 13,728 feet, setting a new depth record for the Mid-Continent area. This well is the third deepest test in the world and the deepest outside of California. It did not find any additional pay zones and has been plugged back and completed in one of the shallower sands.

The trend continues to be toward deeper drilling. It has been an important factor in the discovery of many of these new fields and new sands. On the other hand, it has furnished some disappointing information by showing that some of the productive sand zones grade downdip into much thicker shale zones that are devoid of sand. This is notably true of the Frio, Jackson, and Yegua.

STRUCTURAL INFORMATION

In the past 3 years the number of electrical logs available to the South Texas geologist has increased from approximately 500 to approximately 3,700. Also, more wells and better sampling of well cuttings have enabled the paleontologist to make greater contributions to the geologic knowledge of the area. As a result, subsurface correlations are rapidly becoming a matter of fact rather than a matter of opinion.

It has been found that many of the subsurface strata are folded and faulted to a degree that would have been unbelievable several years ago. The faults appear to be predominantly strike faults, downthrown toward the coast. Most of the faults in the Frio-Vicksburg trend and in the coastal area seem to increase in throw with depth and many have a maximum throw in excess of 400 feet. There is some evidence to support the opinion that at least one or two have a maximum throw greater than 1,000 feet. In the coastal area folds with reverse dips of 100 to more than 400 feet are common. As a general rule the amount of folding increases with depth and in some places there is a lateral shifting of the axis with depth.

CONCLUSIONS

There is no apparent evidence that geological and wildcat activity in South Texas have reached the point of diminishing returns. The reduced number of discoveries in the year 1938 as compared with the year 1937 seems to be the result of a corresponding reduction in the number of wildcat operations, especially during the last 6 months. This reduction is attributed to widespread economic conditions.

The large number of profitable fields discovered and developed in recent years, together with relatively low drilling costs and nearness to marine transportation, will undoubtedly cause operating companies and individuals to look upon South Texas as a favorable area for future exploration and development.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE, 1939), PP. 871-888, 1 FIG.

REVIEW OF DEVELOPMENTS IN 1938, GULF COAST OF SOUTHEAST TEXAS AND LOUISIANA[1]

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ABSTRACT

A progressive change in the outstanding structural type, from major piercement domes with very shallow salt cores, to deeper piercement domes, to deep-seated major closure domes, and finally to the important minor closure features of today, has characterized the history of field discovery on the Gulf Coast since Spindletop. Because of depositional influences that are fundamental to the local occurrence of oil, commercial deposits on the coast are related to geologic and geographic zones, the boundaries of which are arbitrarily recognized.

This change in discovery type partly explains the fact that despite a very active year throughout the coastal districts of Texas and Louisiana during 1938, newly discovered reserves that have resulted from recent exploration do not compare favorably with the totals of previous years. Most of the twenty new producing areas of Louisiana are characterized by production from sands at great depths, where gas-oil ratios are sufficiently high to be a troublesome factor. Of the nine Texas discoveries, three indicate that they may justify a major rating, while the remainder are of unproved potentiality or are of very questionable merit.

Additional discoveries in the Sparta-Wilcox sand zone along the Conroe trend, both in Texas and Louisiana, have assured this area an intensive period of activity for the immediate future. It is generally conceded that this is the most important new Coastal sand development since the discovery of production in the Frio.

Extensions to proved fields and development in deeper sands have added greatly to the reserves in established areas of production during 1938.

INTRODUCTION

During the past four-year period in which the writer has prepared the Gulf Coast Developments Review, there have been many changes in the methods of approach to the problem of oil finding, as well as in the viewpoint of the coastal operator toward this problem. These are but the latter phase of a continuous series of changes that have been taking place since the discovery of oil at Spindletop in 1901 and a brief review of this history might constitute an instructive background against which to consider the activities of the past year.

The technique employed in the search for new oil fields has, of necessity, been undergoing constant change. Initially, the recognition of certain surface manifestations led to the discovery of Spindletop and this method of search subsequently proved very effective in isolating a number of shallow piercement domes. Several of these domes were brought into production immediately following Spindletop, while others, where the productive zones lay at depths beyond the limits of the then available drilling equipment, were delayed in their discovery until a later stage in coastal development.

[1] Read before the Association at Oklahoma City, March 23, 1939.

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The period of geophysical activity that followed upon the decline of the effectiveness of applied surface geology, commenced in 1923–24 with the introduction of the torsion balance and refraction seismograph. The application of this new technique resulted in the discovery of numerous additional domes, mainly those of a type where the salt core lies relatively close to the surface. In many of these discoveries, the instruments merely added confirmation to favorable surface indications that had already been mapped and catalogued, while others pointed the way to anomalies in areas where no previous evidence of structure was known.

From 1931 to the present date, the main exploratory method has been the reflection seismograph. This method has been outstandingly successful in making discovery locations but it has now passed the peak of its effectiveness as far as the Gulf Coast proper is concerned. One reason for the phenomenal early record of the reflection method is that it was first perfected at a time when the oil industry was entering a period of intensive activity and when new drilling equipment made it practical to drill to deeper horizons than had formerly been possible. A great number of prospects that had been given an indefinitely favorable rating by other methods but which had been explored only in the shallow, non-productive section were further studied by the reflection method, with resulting discovery of commercial oil deposits. There were, of course, discoveries during this period that could be credited solely to reflections but in the great majority of cases, reflections were used as a confirming check against previously acquired favorable structural data.

The various exploratory methods that have been applied so intensively in the past appear to have succeeded in locating the majority of existing major domes of orthodox types. In the Review for 1936, it was stated that first class prospects in the Gulf Coast region have been mainly isolated and that the industry must depend for the greater part of its future oil reserves on structural units of second and third class. The idea that it was intended to convey by this statement appears to have been substantiated during the past two years, although the continued discovery of commercial oil in coastal Louisiana on domes of major structural type would seem to be a contradiction. It should be noted, however, that the greater proportion of the recent discoveries in south Louisiana, and to a more limited extent in coastal Texas, have resulted from successful testing of structural prospects that have been recognized as such for many years.

In dealing with soft sediments of the coastal type, all of the geo-

physical methods at present employed and particularly the reflection seismograph, require that a considerable amount of closure be present in order to effectively delineate the structural details of a trap. These methods lose efficiency very notably when dealing with low relief structures, particularly where faulting is a primary factor in creating closure. The second and third class structural units mentioned in the preceeding paragraph are mainly of this latter type.

In August, 1935, the Tepetate field was discovered in Acadia Parish, Louisiana. This constituted a new type of feature for the Gulf Coast, with updip closure formed by faulting and with but a minor amount of reverse dip in the area of accumulation. When the structural details of Tepetate were revealed by drilling, it was regarded as a freak type of structural occurrence which was designated the "Tepetate type" by the geophysicist. Subsequent exploration has uncovered numerous traps somewhat of this nature, where closure is created by faulting and these must be regarded as a very potent factor in accounting for future reserves.

There has been a progressive change in the outstanding structural type that has characterized discovery, from major piercement domes with very shallow salt cores, to deeper piercement domes, to deep-seated major closure domes, and finally to the minor features such as those that constitute an important part of the discoveries of today. This progression naturally resulted as the elimination of major closure features forced refinements in the technique of structural exploration and as it became obvious that the discovery rate must be greatly accelerated to find enough small pools to maintain reserve oil levels established by major fields such as Spindletop, Jennings, and Hastings.

The more impressive recent discovery rate of coastal Louisiana, as compared with the eastern Texas coast, is to be partly attributed to the differences in the physical accessibility of the two regions. The surface sediments of coastal Louisiana, from the Mississippi River westward as far as Cameron Parish, are of distinctly deltaic origin and the marginal lands that extend for many miles inland from the ocean front are swampy and difficult to penetrate. This difficult terrain has delayed development throughout a vast area of highly potential land and has placed Louisiana several years behind Texas in exploiting known structures and in exploring for new domes. The majority of the coastal Louisiana discoveries of the recent past represent a proving of structural anomalies that have been catalogued as such at a much earlier period. Many of these were suggested by early refraction shooting of the late 20's, while others were indicated by subsequent torsion balance work. Since reflection equipment

has been adapted to cope with the difficult swamp conditions that characterize the region, this method has led to several virgin discoveries and has been used for spotting discovery locations on many known structural prospects.

From the standpoint of numbers, the list of discoveries for the Gulf Coast for 1938 is a very impressive one. The apparent total of reserve represented by these discoveries, however, is possibly less important, particularly as applied to Texas, than at any time in the past few years. During the year preceeding 1938, there were fifteen new discoveries for the eastern Texas Coast, as compared with fourteen for Louisiana. Among these there were some outstanding new reserve areas, of which Friendswood in Texas is a striking example. The Louisiana discoveries of that year have been slower in development and less is known about their ultimate possibilities, although there is no indication now that any one of them will approach Friendswood in ultimate yield. New discoveries for the year 1938 total nine for Texas and twenty for Louisiana. Of the nine discoveries credited to Texas, two have but one gas well each at the close of the year, while of the remaining seven, only three may be regarded, on the basis of present development, as definitely representing oil reserves of any great consequence.

No such simple diagnosis may be submitted in regard to Louisiana. Coastal Louisiana differs radically from coastal Texas in the rate at which newly discovered areas are developed. On the Texas side, new productive areas of consequence are rapidly drilled and within a year or two after completion of the first well, the area of production is reasonably well outlined by completions. In Louisiana, however, development is ordinarily slow and there are areas that appeared on the discovery lists for 1937 and 1936, about which it is still difficult to hazard a statement in regard to reserves.

The greater number of the twenty new Louisiana discoveries for 1938 that are listed in this review, are of this category. At the close of the year, many of them are no more than one- and two-well fields and it may require another two-year period in order to accurately appraise them as commercial oil pools.

In the coastal area, there are five general stratigraphic intervals, in order from oldest to youngest: Sparta-Wilcox, grouped together for convenience, productive updip from and within the Conroe zone, Cockfield-Yegua, productive in the Conroe and intermediate zones, and Vicksburg, *Marginulina*-Frio and Miocene, productive in the deep coastal zone. These zones, from oldest to youngest, become potential successively as the coast is approached. The shoreward

phase of each of these petroliferous groups outcrops at the surface. Coastward from the outcrop, there is a progressive gradation within the same series, from distinctly fresh-water deposits, to mixed fresh-water and marine deposits, and finally to sediments of a strictly marine origin. Conditions favorable to the occurrence of commercial oil are best represented within the gradational zone where fresh-water and marine sediments interfinger, situated at a considerable distance coastward from the outcrop. The shoreward margins of such favorable zones are delineated only by arbitrary lines that result from experience: a type group such as the Cockfield-Yegua, for example, having an updip limit that might be said to follow a strike line through northern Montgomery County, northward from which the potentiality of these sands is greatly reduced.

Each successively younger group, in the zone of greatest potentiality, has a distribution that lies generally coastward from the one lying beneath it. The Eocene Wilcox, the oldest productive series on the Gulf Coast, lies farthest inland and the undefined inner margin to the zone in which the possibility of commercial pools seems to be greatest, lies back from the coast a distance greater than 100 miles. At the upper end of the column, the Miocene, the youngest productive group on the coast, has an inner potential zone line that hugs the Texas coast and migrates gradually inland as it progresses across Louisiana.

These zones are characterized downdip by gradations from a section in which sands predominate in the area of interfingering deposits, to one that is essentially shaly in the strictly marine phase. This coastward limit is not to be closely defined because thin sands occurring at considerable distances downdip from the zones of highest potentiality, may be oil bearing. The downdip margin of the zone of greatest potentiality within the Eocene Wilcox, like the updip margin, is still undefined due to the scarcity of drilling data but it is possible that the formation may contain thin sands that are widely distributed through the vertical section, in the coastward phase at great depths. In any event, there are indications that the sands in the downdip distribution of these sediments will be erratic both as to position and character. The Cockfield-Yegua group furnishes production as far south as it has been penetrated under favorable conditions, but sands are more poorly developed in the downdip phase than at Conroe.

The updip margin of commercial *Marginulina*-Frio oil occurrence is fairly well established. This group is productive along a strike line in Texas at Pickett Ridge, Wharton County, Sugarland, Fort Bend County, and West Beaumont, Jefferson County, whereas less than

20 miles inland from this line, Fairbanks, Harris County, Hardin, Liberty County, and Silsbee, Hardin County, are blanketed with a barren *Marginulina*-Frio sand section. Within the favorable zone, because of an abundance of sands, the Frio generally produces gas or gas and oil at the top of the section, but coastward, the vertical distribution of productive zones becomes variable, with reservoir sands occurring at the top or as much as 1,000 feet below the top of the Frio. This group is to be regarded as potential as far south as it may be penetrated on structure.

There is no certainty that oil occurrence will adhere to the rules set out, but variations are sufficiently uncommon that they are a subject of technical interest. During 1938, two new fields at opposite ends of the district are producing Miocene oil under low-relief structural conditions, in areas lying considerably north of normal Miocene oil occurrence. These are Baton Rouge, along the Mississippi River in eastern Louisiana, and Cordele, Jackson County, on the extreme west edge of the district. Miocene oil of low gravity-low octane character at Cordele is found at shallow depths, farther updip than any similar occurrence in this territory, whereas the Baton Rouge oil, occurring at greater depths, is of high octane rating. It is true that most coastal Miocene pools, particularly in Texas, are located many miles inland from the inner margin of the zone of normal Miocene oil occurrence. These, however, are associated with piercement domes where oil is regarded by most geologists as having migrated from underlying Oligocene sources, although it is possible that the true explanation is related to localized depositional influences rather than to the structural history of these domes.

The phenomena that have here been mentioned are directly related to the depositional history of the coast and they are of primary importance in the consideration of the exploratory activity and the development history with which this review is concerned.

DEVELOPMENTS

As in previous years, the discussion of developments will be grouped according to the stratigraphic section from which production is obtained. No attempt will be made to deal at length with the historical background surrounding each discovery as the scope of this paper will not permit an extended discussion.

CONROE TREND

The Conroe trend, where production is normally to be anticipated from the Cockfield-Yegua section, has been inactive during 1938,

except for a slight increase in the exploration for Sparta-Wilcox production. Despite this fact, there were two Cockfield discoveries for the zone during the year, one in each state.

West Conroe.—On December 6, 1938, Housh and Thompson completed their Clary No. 1 in this area for a large gas well in thin Cockfield sands at 4,532–46 feet and 4,730–37 feet. The well flowed an estimated 44 million cubic feet of dry gas per day on open tubing. The location lies 6 miles northwest of the town of Conroe in Montgomery County. Several dry holes were originally drilled to test a torsion-balance prospect, but the discovery location resulted from subsurface interpretation.

Segno and Cleveland.—During the year, the Gulf Production Company found commercial production in sands of Wilcox age below regular Cockfield pay, at both Segno, Polk County, and Cleveland, Liberty County. At Cleveland, their Ragaw No. 2 logged top of Wilcox at 8,100 feet and found saturation in a sand at 8,165 feet. A further interesting development in this deep pay zone resulted just after the close of the year, when Peyton Brothers deepened a well in the Ace area, south-central Polk County, and found commercial production in Wilcox sand at 7,735–55 feet.

In the Joe's Lake (Spurger) area, Tyler County, where Wilcox production was discovered in 1937, developments during 1938 indicate a field of major proportions, with excellent sand conditions.

Bancroft.—This Louisiana discovery, located in Beauregard Parish, three miles east of the Texas state line, is of particular importance because it is the first commercial oil developed on this trend in western Louisiana. Accumulation in this area occurs along a structural nose, on the downthrown coastward side of a strike fault. The discovery well, Republic Production Co.-Lutcher Moore No. 1, was completed for gas and distillate production on May 12, 1938, in Yegua sand at 7,574 feet. The first oil well, Columbia Land Co. No. 1, was completed in a sand at the top of the Yegua at 7,296–7,338 feet for 630 barrels per day on ¼-inch choke. At the close of the year, five commercial wells were on production.

The Bancroft discovery resulted from torsion-balance reconnaissance followed by reflection detailing. Eltran was employed for delineating the fault pattern. Subsurface direction is claimed for the oil discovery in the Columbia Land No. 1.

INTERMEDIATE ZONE

The intermediate zone, the downdip continuation of the Conroe trend, has been moderately active in Texas and one outstanding oil

field and two important oil extensions to gas-producing areas have resulted.

Fairbanks.—In June, 1936, the Amerada and Stanolind-Dopslauf No. 1, located in Harris County 15 miles northwest of Houston, was completed as the discovery well of a new field. The area was given the name of Fairbanks, but this was subsequently changed to *Satsuma*. Production in the area immediately surrounding the discovery well has proved disappointing because of erratic sand conditions and high gas ratios.

On January 12, 1938, Amerada-Stanolind completed the Mills No. 1 as a 4-mile northeast extension to Satsuma. Oil was found in Cockfield-Yegua sand at 6,834–63 feet. The area surrounding this extension discovery has been given a new field designation under the original name of Fairbanks.

Satsuma and Fairbanks are a part of the same structural unit, with oil trapped in a pronounced nosing on the downthrow side of a postulated strike fault. The two units form a field that is of major proportions, with production already proved along a zone parallel with the fault for a distance of 7 miles. Although producing from the same general stratigraphic series, Fairbanks has much better sand conditions in the reservoir horizon than Satsuma. Lateral gradations from sand into shale form the barrier that separates the two areas of production. Indefinite structural evidence resulting from torsion-balance and reflection-seismic work led to the initial discovery and to the Fairbanks extension.

Eureka and Bammel.—Eureka and Bammel, both in Harris County, are new discoveries from an oil producing standpoint, although each area has been proved for gas for a number of years. At Eureka, there is evidence of domal uplift in the gas area, with oil accumulated below the gas against the flank. The discovery well, J. W. Frazier-Vollmer No. 1, was completed on March 23, 1938, as a result of subsurface study. The sand at 7,688–7,731 is of upper Yegua age. A long narrow strip of favorable productive acreage has already been proved.

The newly discovered oil area at Bammel is located with the same relation to gas as at Eureka, with no present evidence that faulting has acted in an important manner to effect distribution. The Harrell-Polley No. 1, located on the south flank adjoining the water level, was completed as an oil well in Cockfield sand at 6,255-80 feet, on July 25, 1938. Present production is 100 barrels of fluid, 77 per cent oil per day.

There are no definite geographic boundaries limiting the zones

that are used in this review, but three Louisiana discoveries for 1938 are arbitrarily placed in the intermediate zone. These are *Woodlawn*, *North Tepetate*, and *Baton Rouge*.

Woodlawn.—Woodlawn is a gas-distillate area located in Jefferson Davis Parish, 8 miles northeast of Iowa field. The discovery well was completed by Union Sulphur Company in February, 1938. The Calcasieu National Bank No. 1 was perforated in *Marginulina*-Frio sand at 8,286–88 feet and flowed 20 barrels of 50° gravity distillate daily. Three additional wells have been completed. This area was originally given an indefinitely favorable rating by refractions and was later worked with reflections by George Strake, who drilled two dry holes. Further reflection work was carried out by Union Sulphur before drilling the discovery location.

North Tepetate.—As discussed elsewhere in this review, Tepetate, in Acadia Parish, was classed as a new structural type at the time of discovery in 1935. The recent discovery at North Tepetate is possibly to be regarded as a 4-mile northward extension to Tepetate proper, and a part of the same structural unit. The discovery well, Atlantic-Clump No. 1, lies on the upthrow side of the strike fault that limits Tepetate production on the north and the regular *Marginulina* sand at 7,960–70 feet carries oil at a position 400 feet structurally higher than in the old field. The discovery well was completed in October, 1938, making a large flow of gas and distillate.

Baton Rouge.—Baton Rouge, located in East Baton Rouge Parish on the margin of the Louisiana State University campus, was originally worked with torsion balance and reflection seismograph. Two deep dry holes were drilled prior to discovery. First commercial production resulted from completion of Wm. Helis and Louisiana Crusader-Duplantier No. 1 during March, 1938. This well was finished in Lower Miocene sands at 6,464–91 feet, and five additional wells were placed on production before the close of the year. The area is of particular interest because of the presence of Miocene oil, under low relief structural conditions, at a point considerably north of the inner margin of the normal zone of occurrence. The Baton Rouge oil has an exceptionally high octane rating.

DEEP COASTAL ZONE

The deep coastal zone, as in previous years, furnished most of the discoveries for 1938. Of the twenty-two new productive areas along this trend, sixteen are on the Louisiana side and six in Texas. To carry the analysis farther, of the sixteen new coastal Louisiana fields, the year closed with four discovery wells shut in with no additional wells

drilled and in nine of the new areas, with only the discovery well or the discovery well and one other definitely on production. The majority of these discoveries have proved troublesome because of high gas ratios. Of the new Texas areas, two are still defined only by the discovery gas well.

Armour and North Markham.—These two new productive areas are located in Matagorda County. Armour was discovered on February 18, 1938, and was briefly mentioned in the review for 1937 under the name of "McCroskey." The initial well, Pierce Estate-Pierce No. 1, was completed in *Marginulina*-Frio sand at 6,619–26 feet, after plugging back from 7,374 feet. Armour lies on the south margin of a nest of low relief, faulted traps, located in southeast Wharton County, that include *Withers*, *Magnet*, *Blue Basin*, and *Five Corners*. Discovery resulted immediately from reflection seismic work.

North Markham lies a short distance east of the old *Markham* shallow dome. The Ohio Oil Company-Cornelius No. 1 was completed on September 13, 1938, in a sand at 7,721–60 feet that lies 1,200 feet below the top of the Frio. Surface study, torsion-balance, and reflection surveying all contributed toward discovery. A second well had been completed by the end of the year.

Cedar Point, Chambers County.—This discovery was briefly reported in the 1937 review. This new dome, located a mile offshore in Galveston Bay, was found by Standard of Texas and Salt Dome Oil Company in their State No. 1, in February, 1938. The discovery well made 642 barrels of 36° gravity oil per day on $\frac{1}{4}$-inch choke from the top of the Frio sand at 5,956–6,063 feet. Subsequently, a very promising Miocene sand has been located at approximately 4,400 feet. Discovery may be credited to torsion-balance study.

Cedar Point is generally regarded as one of the outstanding discoveries of the Texas Coast for 1938.

A second discovery by the Salt Dome Oil Company is also located in Chambers County, and is so far of minor importance. This is *South Anahuac*, located about 16 miles northeast of Cedar Point, across Galveston Bay, where Ogden No. 1 was completed on October 17, 1938, as a dry gasser in Frio sand at 7,515–25 feet. Torsion balance and reflections led to discovery. No additional wells have been drilled to date.

Lovell's Lake.—The Glen McCarthy-Broussard No. 1 proved an additional productive area southeast of Cheek, Jefferson County, on February 4, 1938. The discovery well was drilled on a block without specific data as guidance and found high gas ratio oil production in Frio sand at 7,717–32 feet. Initial production was 105 barrels of oil per day on $\frac{9}{64}$-inch choke. In the 1937 review, this discovery was

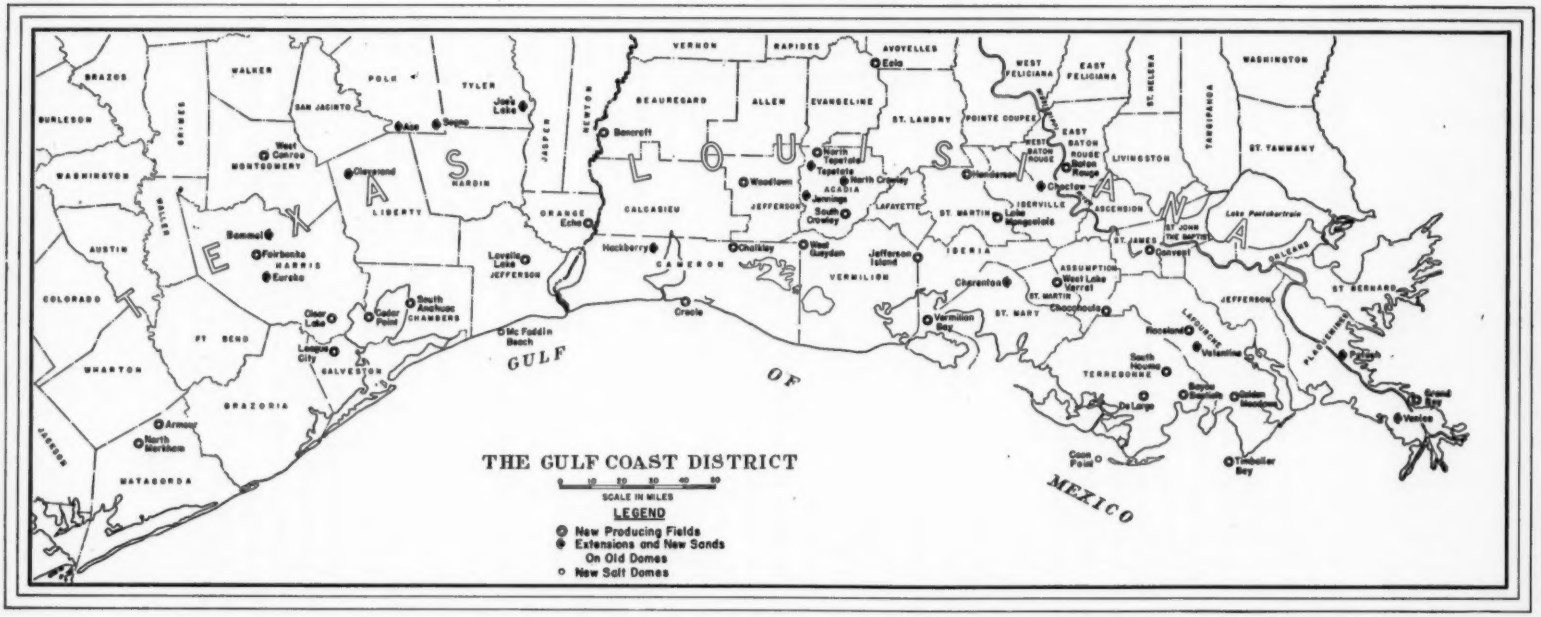

FIG. 1.—Map of Gulf Coast district showing new producing fields; extensions and new sands on old domes; and new salt domes. Only discoveries and extensions of 1938 are shown. Previously discovered fields and domes are omitted in order to preserve the legibility of the map.

mentioned and the new area designated under the name of Cheek. The Magnolia productive area, located 5 miles northwest, was given the new field name of North Cheek. During the year 1938, these productive areas have been reclassified, and a brief history will be given to clarify this situation.

Evidence of a structual anomaly resulted from early refractions in the Cheek area. Reflections in 1931 led to development and five scattered dry holes, most of them too shallow to reach the present pay, were drilled. The Magnolia found Frio production at 8,300 feet at a location 5 miles northwest of the McCarthy discovery in June, 1937, and this discovery was designated the North Cheek field. After the discovery area of the McCarthy-Broussard No. 1 was set out as a new unit under the name of Lovell's Lake, the North Cheek name was changed to Cheek.

Since the completion by McCarthy, the Humble Company has extended production more than a mile both north and northwest so that the field has the appearance of a major feature. A strike fault of considerable displacement that is downthrown coastward, is primarily responsible for the accumulation at Lovell's Lake. This fault extends across the area that separates Lovell's Lake and Cheek.

Clear Lake.—Clear Lake is located in Harris County, northeast of *Friendswood*. It was found by the West Production Company-Snowden No. 1, April 7, 1938. The Frio sand at 5,790–6,030 feet produced gas and distillate upon completion. Several additional wells have been placed on production since that date, but because of a policy of secrecy adopted by the operators, little is generally known about either sand conditions or structure. The presence of local uplift was suggested by early torsion-balance work, with subsequent reflections leading to development.

The West properties, which incorporate both the Clear Lake area and a considerable portion of the east side of *Friendswood*, have recently been purchased by the Humble Company.

League City.—This Galveston County field is the last Texas discovery of the year. It is located approximately 5 miles west of Dickinson, with production occurring at a structural position lower than the crest of the *Dickinson* dome. Present data indicate that the area of accumulation may lie in a downthrown fault block.

The discovery well, Midwest-Lobit No. 1, completed October 22, 1938, is reported to have been located on surface evidence, with a probable additional background of geophysics. Production was found in a sand at 9,092 feet, approximately 1,000 feet below the top of the Frio. Two of the five wells completed since discovery have been dry holes.

Immediately off the Jefferson County coast in the Gulf of Mexico, the Humble-State No. 1 found shallow salt on a new dome that has been designated *McFaddin Beach*. Cap rock was encountered at 1,412 feet and salt at 2,603 feet. The test was abandoned on May 11, 1938, with no showings of oil or gas recorded.

The new fields for deep coastal Louisiana for 1938 are as follows:

Creole.—This discovery resulted in March, 1938, from drilling in the Gulf of Mexico, one mile off the Cameron Parish shore. The discovery well, Superior Oil Co. of California-State No. 1, found production in Upper Miocene sand at 5,110–30 feet. Three wells have been completed since discovery. The initial well was located to test a favorable reflection-seismic picture.

Chalkley, Cameron Parish.—This field is located at the southeast corner of Calcasieu Parish. The Humble-Hanszen No. 1, completed in Lower Miocene sand through perforations at 8,562–68 feet during November, 1938, is a small gas-distillate producer. Since completion of the discovery gas well, three tests have been drilled and abandoned. A fifth test is now drilling. Discovery at Chalkley resulted directly from reflection-seismic surveying.

West Gueydan.—An early torsion-balance picture that was defined by reflections led to prospecting in this Vermilion Parish area. The Magnolia-Ferguson No. 1 found gas during July, 1938, in Lower Miocene sand through perforations at 7,140–50 feet. Two deep dry flank tests have subsequently been drilled.

South Crowley, Acadia Parish.—Like West Gueydan, this new area that lies to the southwest of the very prolific Jennings dome, can not be appraised as to its future possibilities. The discovery well was drilled by the Humble on the Boyd Finch tract to a depth of 12,216 feet, but was plugged back to a Lower Miocene sand at 7,318 feet for completion. The well was finished in May, 1938, but was later invaded by salt water and has been off production for some time. Subsequently, three dry holes have been completed on the dome. Difficulty in completing producers is laid to the very complex fault pattern that is known to affect the dome.

Credit for the delineation of this structural feature belongs to torsion balance and reflections.

Jefferson Island.—This dome in Iberia Parish is one of the so-called five islands and is the first of the group to produce commercial oil. It was one of the first domes to be recognized as such in south Louisiana because of its surface expression and it has been mined for salt for 20 years. The successful completion of the first oil well results from flank development and this is to be regarded as one of the important coastal Louisiana discoveries for 1938.

The discovery well, The Texas Company-Jefferson Island Salt Co. No. 1, was completed in June in Lower Miocene sand through perforations at 7,827–37 feet. It was later perforated in a deeper sand at 8,170–8,210 feet.

Vermilion Bay.—This new area is located in Vermilion Bay, 4 miles off the Iberia Parish coast. The presence of a dome was indicated by early geophysics and numerous unsuccessful tests have been drilled on the uplift.

The discovery well was drilled by The Texas Company during June, 1938, and encountered tremendous gas pressures in a thick sand series of Miocene age at 9,667–9,900 feet. The well blew out, killing one man and causing great damage. Just recently, plans have been perfected for reworking the old hole and attempting a completion.

West Lake Verret.—This area in St. Martin Parish is one of several prospects that resulted from the prolonged reflection-seismic activities of the Shell in south Louisiana. The Shell-Burdin No. 1 at West Lake Verret was completed during December through perforations in Miocene sand at 8,017–20 feet, after two dry holes had been drilled. Initial production was 282 barrels of oil and 460 barrels of water per day on ¼-inch choke. A fourth well is now drilling.

Golden Meadows.—This discovery, in La Fourche Parish, lies between *Leeville* and *Bayou Baptiste*. The first well, The Texas Co.-Latavel Land Co. No. 1 is located on a reflection-seismic prospect that centers ½ mile southwest of the town of Golden Meadows. It was completed on December 31, 1938, in Lower Miocene sand at 8,500–20 feet, after plugging back from 11,135 feet. Initial production of 1,000 barrels of oil daily, through ¼-inch choke was obtained but water encroachment up to 40 per cent of the fluid soon occurred. This well has since been reworked for 225 barrels of clean oil daily, and a second well is nearing completion. The local presence of a structural anomoly was suggested by early torsion-balance work.

Three new fields were found in the swampy delta area of southeast Terrebonne Parish during the year. These are *De Large, Bayou Baptiste,* and *South Houma*. The first two were discovered by Fohs Oil Company and the third by Shell. At the close of the year, each is a one-well field, producing with high gas ratios from sands below 10,000 feet. All three discoveries resulted from reflection refinements of earlier torsion-balance or refraction work.

At *De Large,* during June, 1938, Fohs Oil Company completed their Buckley Burg No. 1, located immediately west of the town of De Large in Sec. 72, T. 19 S., R. 17 E. The Lower Miocene sand from

which heavy production of gas and distillate is obtained was perforated at 13,254–266 feet. This well holds the world's record for the deepest commercially productive zone ever penetrated by drilling.

The second Fohs discovery, at Bayou Baptiste, was found during August, 1938, at a point 3 miles southeast of Lirette. This has been classed as a new field, but there are indications that Bayou Baptiste and *Lirette* are a common structural unit, with the new field on an upthrown block. The Bayou Baptiste No. 1 was completed as a gas and distillate well through perforations at 11,172–178 feet in a sand of Lower Miocene age. Neither of these Fohs discovery areas has been prospected further.

The Shell discovery at South Houma was completed in November. The Peters No. 1 was finished through perforations at 10,315–408 feet, in sand of Lower Miocene age. The well came in with high gas ratios, making 490 barrels per day of 36.9° gravity oil. A second test is now drilling. This is an old prospect that has been recognized since early refraction days.

Timbalier Bay.—This discovery of the Gulf Production Company, located in the Gulf of Mexico off the La Fourche Parish shore, was reported briefly in the review for 1937. The discovery well, State P.P. No. 3, was completed on January 1, 1938, in Middle Miocene sand at 6,955–63 feet. Development has been very unsatisfactory in this new area and there were no producing wells at the close of the year. Subsequently, No. 3 and No. 4 have been brought back for a combined output of 200 barrels per day. Discovery was made on an old gravimeter picture that was checked by reflections.

Grand Bay.—This is the second discovery of the Gulf Production Co. during 1938. The field is located in the water off the east side of the present Mississippi delta in Plaquemines Parish. The discovery well, Grand Prairie Levee Dist. No. 1-AA, was completed through perforations in Lower Miocene sand at 6,133–51 feet in July, 1938. Two wells had been completed at the end of the year. Recent reflection seismic work, after old refractions, is credited with discovery.

Raceland.—The Amerada Petroleum Corporation brought in the first well of the Raceland field, north-central La Fourche Parish, on January 30, 1938. The discovery well, South Coast No. 1, was completed in Lower Miocene sand at 10,183–201 feet. In the second well, a new sand was found at 7,174–90 feet. At the close of the year, there were three completed wells making 1,350 barrels of oil per day.

Like most of the other Atchafalaya basin discoveries, Raceland is to be credited to refractions with later reflections. The refraction background was produced rather recently in this instance.

Chacahoula.—Chacahoula is an old dome in upper La Fourche Parish that was isolated by the refraction seismograph in 1925. Many shallow oil and sulphur tests were drilled through a period of years without establishing production. The present discovery results from deep flank testing by the Sun Oil Company. Their Stark-Brown No. 2 found production in Lower Miocene sand at 7,240–69 feet, during September, 1938. A second successful completion has been made.

Convent.—Convent, located astride the Mississippi River in St. James Parish, was reported as a salt discovery in 1936. In July of the past year, the Continental Oil Company, on a farm-out from the Shell, completed their Realty Operators No. 1 for a high-ratio well in Lower Miocene sand at 6,358–74 feet. Initial production was 240 barrels, 45 per cent salt water. This is an old refraction high that was later worked with torsion balance and reflections. No additional wells have been drilled on this prospect.

IMPORTANT EXTENSIONS

In Louisiana, numerous new sands were developed in established fields that add greatly to the known reserves of the region. At *North Crowley*, Acadia Parish, the Humble Company found their third and deepest sand at 8,610 feet. At *Venice*, Plaquemines Parish, flank development by Tide Water has located favorable producing zones at 3,600 and 5,600 feet. At *Charenton*, the Pan American and Barnsdall dome in St. Mary Parish, four productive sands are now being operated from 1,100, 1,800, 2,600 and 6,875 feet. All of these are of Miocene age. The probable recovery at *Tepetate*, Acadia Parish, has been materially increased by the development of a new deep Frio sand at 9,180 feet. This zone lies approximately 800 feet below the regular *Marginulina*-Frio pay zone.

One of the interesting Louisiana developments of the year is the discovery by Lousiana Crusader and Standard of Louisiana of Oligocene oil on the north flank of *Choctaw* dome, located on the Iberville-West Baton Rouge Parish line. Regular production has been from Miocene flank sands on the east side of the salt mass. Previous to this development, oil-bearing sands of Oligocene age were not considered potential so far east in Louisiana.

Important extensions occurred at *Valentine*, La Fourche Parish, where Wm. Helis developed good production on the west flank, and at *Jennings*, Acadia Parish. At the latter location, Superior of California uncovered another prolific spot on the northwest flank of the dome, and the Gulf Company extended deep production northward along

the east flank. At *Hackberry*, Cameron Parish, Superior of California also developed important *Marginulina*-Frio production on the southwest flank of the dome in sands at 6,500 feet.

Ten miles off the Terrebonne Parish shore in the Gulf of Mexico, The Texas Company encountered salt at 4,922 feet on the *Coon Point* prospect. Favorable showings of oil or gas are reported to have been logged.

OUTSTANDING PLAYS UNSUCCESSFUL TO DATE

Of the various areas specifically mentioned under this heading in the 1937 review, only one, *Chalkley* (Hanszen) in Cameron Parish, has had a commercial completion during 1938. During the past year, several highly regarded wildcat areas not previously mentioned have proved disappointing.

There is an important difference in the fundamental status of non-productive prospects in Louisiana and Texas. At any one time, the majority of the active prospects on the Texas side consist of recent anomalies, usually of the deep-seated, low-relief type. Major domes that have not yielded commercial oil after intensive prospecting, but which are carried on the list as active prospects, are relatively rare, although there are important exceptions, such as *Hockley*, *Davis Hill*, and *San Felipe*, located along the updip margin of the main salt area where potentiality is to be questioned, and *Big Hill*, *Lost Lake*, and *Stratton Ridge* in the deep coastal zone.

In Louisiana there are a great many unproductive major domes, both of shallow and intermediate salt types, that are being actively prospected from year to year. At the close of the year 1938, three of these were outstanding in the disappointing results obtained, although tests on two of them have shown encouraging results since the year ended. These domes are *Henderson* and *Lake Mongoulois*, both in St. Martin Parish, and *Bay Marchand* in La Fourche Parish.

Henderson and Lake Mongoulois are under development by The Texas Company. After nine failures, the tenth well is being drilled at Henderson and it is reported that showings of oil indicating commercial production have been obtained. At Lake Mongoulois, eight or nine dry holes have been drilled, but the well now drilling, State No. 6, has been perforated in Lower Miocene sand at 9,676–96 feet and is in the process of completion. Bay Marchand, one of the largest salt uplifts on the coast, has had no successful completion.

Numerous other outstanding prospects have suffered further setbacks during the year, but there is not space in this review to discuss them separately.

IMPORTANT AREAS UNDER EXPLORATION

The relative importance of the zones along the coast that are being actively explored, has varied little during the past two years. As was stated in a previous review, the centers of most intensive activity tend to move from one locality to another in the wake of successful exploration. This statement still holds true.

The development of several fine fields in Sparta-Wilcox sands along the inner coastal margin, has centered attention further on the potentialities of this zone and the most important play of the immediate future will unquestionably be concentrated along the Conroe trend, particularly in the territory between *Joe's Lake* and *Ville Platte*. When considered from a structural standpoint, it is probable that the influence of strike faults will be found a very important factor in the creation of traps throughout this trend.

Interest along this trend has been heightened during January, 1939, by the completion of a new discovery well on the *Eola* prospect, Avoyelles Parish, by Sid Richardson. The well is showing for large initial production of 43° gravity oil from Wilcox sand at 8,440–45 feet. This new prospect lies between Cheneyville and Ville Platte fields.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL 23, NO. 6 (JUNE, 1939), PP. 889-895, 1 FIG.

DEVELOPMENT IN EAST TEXAS DURING 1938[1]

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ABSTRACT

Two new oil-producing areas, two new gas-distillate areas, and oil production in two old gas fields were discovered in East Texas during 1938. Areal extensions were added to two fields. Many of the important exploratory tests were directed to the Paluxy, lower Glen Rose, and Travis Peak formations (Lower Cretaceous). Some of these tests were located on proved structural features previously condemned in shallower formations, and others were located in proved fields. Several of the deeper tests penetrated zones which added materially to the knowledge of the Trinity and pre-Trinity (?) stratigraphy of the East Texas basin.

INTRODUCTION

The East Texas district, as discussed in this paper, embraces forty-four counties (Fig. 1) in the northeast part of the state and covers an area of approximately 37,000 square miles.

Two oil-producing areas, two gas and distillate areas, and oil production in two old gas fields were discovered in the district during 1938. In all, 2,213 wells were drilled with the following results.

Oil wells	2,014
Gas and distillate wells	37
Dry holes (fields)	61
Dry holes (exploratory tests)	101
Total	2,213

The number of completions in the district decreased approximately 35 per cent during 1938, as compared with 1937, due mainly to the decline of drilling operations in the East Texas field.

Considerable exploratory drilling was directed to the Lower Cretaceous formations (mainly Paluxy, lower Glen Rose, and Travis Peak) on known structures, some of which had already been condemned for shallower production. Several deep tests were drilled in proved fields.

On January 1, 1939, there were 49 active operations in the district. Thirty-seven of these were drilling in proved areas and 12 were exploratory tests.

NEW FIELDS AND PRODUCING AREAS

Chapel Hill (Smith County).—The Chapel Hill area, located about 10 miles east of Tyler and 10 miles west of the East Texas oil field, was

[1] Presented by title before the Association at Oklahoma City, March 23, 1939. Manuscript received, April 20, 1939.

[2] Humble Oil and Refining Company.

[3] Hudnall and Pirtle, consulting geologists.

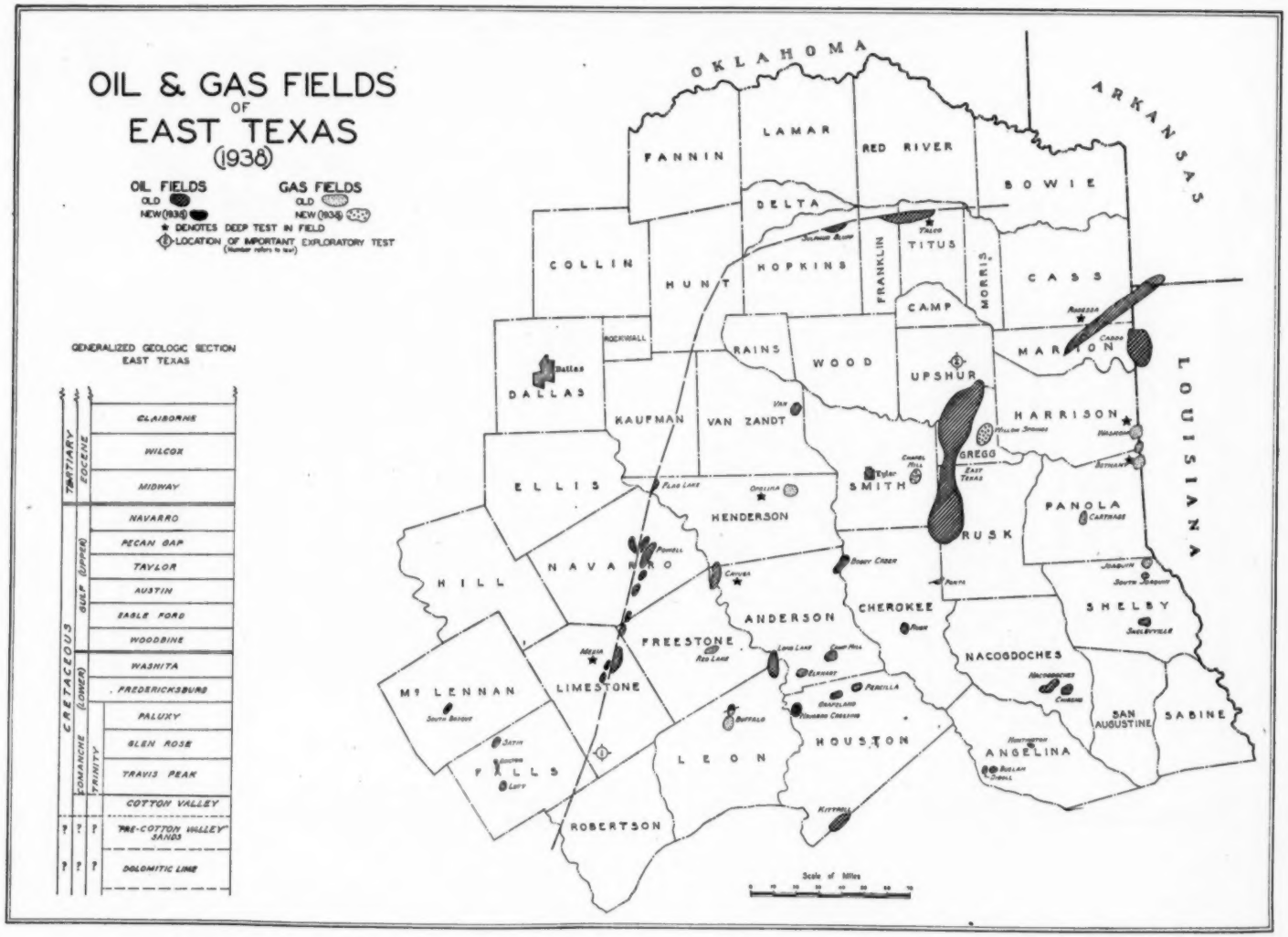


FIG. 1.—Index map of East Texas oil and gas fields (December 31, 1938), and important exploratory tests drilled in 1938

discovered by the Hunt Oil Company's Bradley No. 1, completed July 13, 1938, at a total depth of 7,528 feet. This well had an initial production of 4 million cubic feet of gas and 250 barrels of 61° gravity distillate on a $\frac{3}{8}$-inch tubing choke. It is producing from the Rodessa zone in the lower Glen Rose section, and is the only deep well that has been drilled in the area. Gas from the Bradley well has been piped to the East Texas field, where it is utilized in gas lift operations. The presence of structure in the Chapel Hill area was first indicated by surface geology. This was followed by subsurface work after two early Woodbine tests were drilled. Subsequent geophysical work confirmed the presence of structure on the lower beds.

Navarro Crossing (*Houston County*).—The most important development during the year was the discovery of oil production in the Navarro Crossing area in Houston County. The discovery well, the Humble Oil and Refining Company's Dailey No. 1, was completed, April 23, 1938, at a total depth of 5,920 feet in the Woodbine formation. Initial production was 296 barrels of 36° gravity oil per day through a $\frac{1}{4}$-inch choke, with a gas-oil ratio of 4,420 cubic feet per barrel. The field is now in the process of being developed, and during 1938 a total of 4 oil wells, 3 gas wells, and 1 dry hole were drilled. The type of structure is domal, being first indicated by surface geology and later further defined by core drilling and geophysical work.

Ponta (*Cherokee County*).—The Ponta area has received considerable development during the past few years, and several wells encountered showings of oil. The first producer, the John R. Bunn *et al.* Bounds No. 1, was completed, May 6, 1938, at a depth of 4,014 feet in the Woodbine sand, with an initial daily production of 268 barrels of 35.2° gravity oil and 60–75 per cent basic sediment and water. Two other small wells were completed during 1938. The total production from the area to January 1, 1939, was 3,320 barrels.

These wells are located on the upthrown and south side of an east-west trending fault, the presence of which was established several years ago by surface work.

Willow Springs (*Gregg County*).—During 1938, the Humble Oil and Refining Company and the Gulf Oil Corporation opened a new gas-producing area from the Pettit zone of the lower Glen Rose, located 3 miles east of the East Texas field and 2 miles southwest of Longview in the eastern part of Gregg County, Texas. Two wells have been completed in this area. The first well, Robertson No. 1, was completed, July 12, 1938, through casing perforations at a depth of 7,244–7,276 feet with an initial daily production of 4,080,000 cubic feet of gas and 42 barrels of distillate through $\frac{1}{4}$-inch choke.

FIG. 1.—Index map of East Texas oil and gas fields (December 31, 1938), and important exploratory tests drilled in 1938

This well was originally drilled to a total depth of 10,284 feet, testing sands in the Travis Peak and Cotton Valley formations which showed water. The second well, Horton and Dixon No. 1, located 1¾ miles southwest of the Robertson well, was completed, October 8, 1938, at a depth of 7,305 feet in the Pettit, with an initial daily production of 7,270,000 cubic feet of gas and a spray of distillate through a ⅜-inch choke. The structure in this area was first indicated by surface geology and was later confirmed by core drill and geophysical work.

FIELD EXTENSIONS AND DEVELOPMENTS

Bethany (*Panola County*).—The Texas Company's Adams No. 1 deep test, in the old Bethany field, was drilled to a depth of 11,303 feet, where it was completed in salt. Top of the salt was encountered at 11,067 feet. After testing water in the Travis Peak and Cotton Valley formations, this well was plugged back to a depth of 5,780 feet, where it was completed, November 11, 1938, in the Pettit section of the lower Glen Rose, with an initial production of 13 million cubic feet of gas and 32 barrels of distillate per day through open 2½-inch tubing.

Buffalo (*Leon County*).—The J. K. Hughes *et al.* Bane No. 1 proved a north extension to the Buffalo gas field, and is the only well in the area that has produced oil. This well was completed, November 7, 1938, at a plugged back depth of 5,524 feet in the Woodbine sand, with an initial production of 170 barrels of 25.4° gravity oil and 40 per cent water, with a gas-oil ratio of 2,942 cubic feet per barrel. This small oil-producing area is separated from the gas area on the south by an east-west trending fault with the upthrown side on the north. In addition to the Bane No. 1, there were three Woodbine gas wells completed in the field during the year.

Cayuga (*Anderson, Freestone, and Henderson counties*).—During 1938, 41 oil wells, 4 gas-distillate wells, and 1 dry hole were completed in the Cayuga oil and gas pool from the Woodbine formation at an average depth of 4,000 feet. One well, Roeser and Pendleton's Bowyer No. 3, was completed for a gas-distillate well at a depth of 7,640 feet in the Rodessa zone of the lower Glen Rose, with an initial production of 4 million cubic feet of gas and 260 barrels of distillate through ⅜-inch choke. This well was originally drilled to the lower Glen Rose in 1937, but due to mechanical difficulties was never successfully completed. It was plugged back and produced for several months from the Woodbine, after which it was re-drilled and successfully completed in the lower zone.

The fourth Glen Rose test for the pool, the Barnsdall Oil Com-

pany's Tubbs No. 2, was in the process of being completed as a gas-distillate well on January 1, 1939. This is the first deep well to be drilled on the east flank of the Cayuga structure.

East Texas field (*Gregg, Rusk, Upshur, Smith, and Cherokee counties*).—Drilling activity in the East Texas field gradually declined during 1938. There were 77 active drilling rigs in operation at the beginning of the year, compared with 25 drilling rigs at the end of the year.

During 1938, there were 1,735 oil wells (Woodbine) completed in the East Texas field, making a total of 25,891 producing wells. A total of 327 wells have been abandoned. The field embraces a proved oil area of approximately 134,000 acres. The cumulative oil production to January 1, 1939, is estimated at 1,328,591,000 barrels. At the end of the year, the daily average production for the field was 387,000 barrels from 19,295 flowing wells, 5,995 pumping wells and 601 gas-lift wells. Approximately 4,100 wells were making water, with a daily average water production estimated at 123,000 barrels.

Flag Lake field (*Henderson County*).—Thirteen oil wells, 1 gas well, and 6 dry holes were completed in the Woodbine at Flag Lake during 1938. All wells are on the pump and are showing some water.

Grapeland (*Houston County*).—Only one well was drilled to the Woodbine in the Grapeland district during the year, which was abandoned as a dry hole.

Joaquin (*Shelby County*).—Redditt and Gray's Pickering Lumber Company No. 2, drilled to a depth of 5,131 feet in the Joaquin area, was of interest in that this test produced some 47.3° gravity oil from the Rodessa zone of the lower Glen Rose. This area previously had produced only gas and distillate. On December 5, 1938, the well produced 72 barrels of oil and approximately 8 million cubic feet of gas per day. Operators made various attempts to lower the gas-oil ratio without success.

Long Lake (*Anderson, Freestone, and Leon counties*).—During 1938, 25 oil wells, 12 gas-distillate wells, and 2 dry holes were completed in the Woodbine formation.

Mexia (*Limestone County*).—The Pure Oil Company's Kendrick No. T-16 was abandoned, January 31, 1938, at a depth of 8,847 feet in dolomitic limestone. This test revealed the presence of the Cotton Valley formation on the west side of the East Texas basin. It also encountered a dolomitic limestone from 8,765 feet to the total depth of 8,847 feet, which is believed to correlate with the Smackover limestone of southern Arkansas. No showings of oil or gas were encountered in either of these formations. Some slight oil showings were

found in the lower Glen Rose and Travis Peak, which upon testing were either dry or showed salt water.

Opelika (*Henderson County*).—The Tide Water-Seaboard-Humble's McGee No. 1, located on the northwest flank of the Opelika dome, was drilling at a depth of 7,465 feet at the close of the year. During the early part of 1939, this test was completed as a gas-distillate well from the lower Glen Rose, flowing 7,892,000 cubic feet of gas and 436 barrels of 61° gravity distillate per day.

Percilla (*Houston County*).—Efforts to obtain additional Woodbine production during 1938 in the Percilla area were unsuccessful. Three tests were drilled during the year, each resulting in abandonment.

Rodessa (*Cass and Marion counties*).—During 1938, the Rodessa field was extended 4.5 miles southwest, to approximately 3 miles southwest of Jefferson. The first well in this extension, the Arkansas Fuel Oil Company's Pitts No. 1, was originally drilled to a depth of 7,071 feet in the Travis Peak formation. The lower zones were found unproductive, and the well was plugged back to the Hill sand in the lower Glen Rose, encountered at a depth of 5,930 feet, and successfully completed with an initial production of 6,500,000 cubic feet of gas. The new extension area has produced only gas from the 4 wells that have been completed. During 1938, 102 oil wells, 7 gas-distillate wells, and 1 dry hole were completed. The total oil- and gas-producing area embraces approximately 22,000 acres, with 10,500 acres being oil productive. The productive limits of the field have been fairly well defined.

Sulphur Bluff (*Hopkins County*).—The only well completed in this field was Goldston *et al.* Smith No. 10, which was drilled in an attempt to find production below the present producing Paluxy sand. This well was drilled to a depth of 6,600 feet in the upper part of the Travis Peak formation. The only showing encountered below the Paluxy was found immediately below the massive anhydrite at a depth of 5,710 feet. The well was plugged back to a depth of 4,600 feet and completed as a Paluxy producer. The total proved area of the Sulphur Bluff field is approximately 1,100 acres. The daily average production at the end of the year was 4,600 barrels, and the cumulative production totaled 3,315,000 barrels.

Talco (*Franklin and Titus counties*).—In the Talco field, 77 oil wells and 4 dry holes were completed during 1938. There were 699 producing wells at the end of the year and 14 wells had been abandoned. The third deep test for the field, the Ajo Oil Company's Sanders No. 1, located west of the Talco townsite, was drilled to a

depth of 5,903 feet in the upper part of the Travis Peak formation. A number of minor showings were encountered in this well, and a sand section in the lower Glen Rose carried an oil stain, but tested salt water. The proved area of the Talco field embraces approximately 10,500 acres. The daily average production at the end of the year was 30,000 barrels. Cumulative production to January 1, 1939, was 20,500,000 barrels.

Van (*Van Zandt County*).—In the Van field, 3 Woodbine wells and 4 Nacatoch wells were drilled during the year. Only 1 Woodbine well and 1 Nacatoch well were completed as producers. The Van field embraces a productive area of 4,500 acres. On January 1, 1939, there were 559 producing wells in the Woodbine sand.

Waskom (*Harrison County*).—The most important development in the Waskom area was the completion of the Arkansas-Louisiana Gas Company's Abney No. 1, which was the first deep producer for this field. This well was drilled to a depth of 5,123 feet and then plugged back to 4,834 feet, where it was completed in the Rodessa zone of the lower Glen Rose with an initial production of 18 million cubic feet of gas.

IMPORTANT EXPLORATORY TESTS

Upshur County.—On the Kelsey dome in Upshur County, the American Liberty Oil Company and T. F. Hunter abandoned their Carter No. 1 (*2*)[4] on June 5, 1938, at a depth of 9,538 feet in the lower Travis Peak formation. No showings of oil and gas were encountered in this well with the exception of some slight oil showings found in the upper part of the Travis Peak.

Limestone County.—The Stanolind Oil and Gas Company's Norris No. 1, (1) southwest of Kosse, was abandoned, April 17, 1938, at a depth of 9,951 feet. This well encountered a showing of gas in approximately 100 feet of porous limestone in the upper part of a 460-foot limestone section encountered at 8,525 feet. This formation is believed to be correlative with the Smackover limestone of southern Arkansas. Below the limestone, a bed of salt 790 feet thick was penetrated, which in turn was underlain by anhydrite and a series of sands and conglomerates to a depth of 9,951 feet. It is significant that both this well and the Pure Oil Company's Kendrick No. T-16 in the Mexia field encountered good porosity in what is generally believed to be the correlative of the Smackover limestone on the west side of the East Texas basin.

[4] Italic numerals in parentheses refer to numbers in Figure 1, indicating locations of important exploratory tests drilled during 1938.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE, 1939), PP. 896-902, 1 FIG.

DEVELOPMENT IN SOUTHERN ARKANSAS AND NORTHERN LOUISIANA IN 1938[1]

W. C. SPOONER[2]
Shreveport, Louisiana

The development in southern Arkansas and northern Louisiana during 1938 was primarily in search of oil and gas from the Glen Rose formation, the Cotton Valley formation, and the Smackover limestone.

The wells drilled outside of the producing fields and the discovery wells are listed in Table I.

The discoveries during the year are listed as follows.

ARKANSAS

Magnolia field	T. 17 S., R. 20 W., Columbia County
Discovery well	Kerr-Lynn Oil Co.'s Barnet No. 1 Sec. 14, T. 17 S., R. 20 W.
Producing zone	Smackover limestone. Depth, 7,730 feet
Village field	T. 17 S., R. 19 W., Columbia County
Discovery well	Standard Oil Co.'s Phillips No. 1 Sec. 15, T. 17 S., R. 19 W.
Producing zone	Smackover limestone. Depth, 7,603 feet
Atlanta field	T. 18 S., R. 19 W., Columbia County
Discovery well	Tidewater-Seaboard's Beene No. 1 Sec. 15 T., 18 S., R. 19 W.
Producing zone	Smackover limestone. Depth, 8,332 feet
Falcon field	T. 15 S., R. 22 W., Nevada County
Discovery well	Texas Canadian Oil Co.'s Stocks No. 1 Sec. 9, T. 15 S., R. 22 W.
Producing zone	Nacatoch sand. Depth, 1,300 feet

LOUISIANA

Shreveport field	T. 17 N., R. 14 W., Caddo Parish
Discovery well	R. E. Allison's Ellerbe No. 1 Sec. 27, T. 17 N., R. 14 W.
Producing zone	Pettit zone (lower Glen Rose). Depth, 5,582 feet

New producing zones have been found in the developed Caddo, Cotton Valley, and Shongaloo fields of Louisiana.

In the Caddo field, Vivian district, the Colonial Oil Company's Thigpen and Herold No. 1, Sec. 34, T. 22 N., R. 16 W., was completed as an oil producer in the Tokio. That discovery led to considerable drilling in the area with oil production discovered in the Paluxy sand. The production is principally from thin lenticular sands and is not a major discovery.

In the Cotton Valley field, producing principally gas and distillate from several sands in the Cotton Valley formation, flank production

[1] Presented by title before the Association at Oklahoma City, March 23, 1939. Manuscript received, May 2, 1939.

[2] Consulting geologist, Atlas Building.

TABLE I

Company and Farm	*Section, Township, Range*	*Feet Total Depth*	*Bottom of Hole in*
LOUISIANA			
BIENVILLE PARISH			
De Soto Oil & Gas Co.—Fleming No. 1	18-16N- 9W	5,525	Travis Peak
Gulf Refg. Co.—Goodpine Lbr. Co. No. 1	25-14N- 8W	10,951	Cotton Valley
Producers O. & G. Co.—W. C. Locke No. 1	9-15N-10W	5,407	Lower Glen Rose
BOSSIER PARISH			
W. M. Chambers—J. N. Thomas No. 1	10-22N-11W	3,197	Tokio
CADDO PARISH			
R. E. Allison—Ellerbe No. 1	27-18N-14W	6,025	Travis Peak
Arkansas La. Gas Co.—F. F. Webb No. 1	4-16N-13W	6,017	Travis Peak
Colonial Corp.—Thigpen & Herold No. 1	34-22N-16W	4,865	Lower Glen Rose
Hollywood O. Corp.—C. & B. Realty Co. No. 1	22-17N-14W	6,009	Travis Peak
F. W. Martin *et al.*—Querbes No. 1	37-17N-13W	6,155	Travis Peak
Oils, Inc.—A. Cazeaux No. 1	16-16N-13W	3,462	Paluxy
CALDWELL PARISH			
G. W. Zeigen—La. Cent. Lbr. Co. No. 1	20-14N- 3E	1,767	Wilcox
G. W. Zeigen—La. Cent. Lbr. Co. No. 14	20-14N- 3E	1,766	Wilcox
CLAIBORNE PARISH			
W. L. McClanahan—J. T. Lewis No. 1	25-20N- 7W	5,507	Glen Rose
Union Prod. Co.—Brownfield No. 2	5-19N- 5W	10,759	Cotton Valley or older
DE SOTO PARISH			
Clear Lake O. Co.—Wolluns No. 1	29-12N-12W	2,690	Paluxy
La. Seaboard O. Refg. Co.—Lawrence No. 1	36-12N-14W	2,894	Paluxy
F. L. Miller—Jal. Drlg. Co. No. 2	5-11N-11W	4,040	Lower Glen Rose
The Hunter Co.—Parker No. 1	36-12N-16W	5,187	Lower Glen Rose
Alexander *et al.*—Stell No. 1	5-12N-16W	6,002	Lower Glen Rose
FRANKLIN PARISH			
Southern Star. Pet. Co.—Grayson No. 2	36-12N- 6E	1,754	Sparta
No. 3	36-12N- 6E	2,802	Wilcox
LA SALLE PARISH			
Placid O. Co.—La. Cent. L. Co. No. 5	12- 9N- 2E	1,850	Wilcox
No. 6	20-10N- 4E	1,851	Wilcox
Trechelle *et al.*—Gallagher and Tannehill No. 1	31- 9N- 2E	1,751	Wilcox
LINCOLN PARISH			
Ludel O. Corp.—M. L. Gill No. 1	36-20N- 2W	6,000	Travis Peak
Oakes & Easton—N. L. Griggs No. 1	36-18N- 1W	6,259	Travis Peak
MADISON PARISH			
Continental O. Co.—Singer Mfg. Co. No. 1	3-15N-11E	4,334	Salt
No. 2	2-15N-11E	4,486	Midway
MOREHOUSE PARISH			
Hunter-Rowe *et al.*—E. M. Clark No. 1	10-20N- 7E	7,023	Smackover limestone or older
NATCHITOCHES PARISH			
W. P. Ryan *et al.*—Lambert No. 1	4- 8N- 9W	4,133	Paluxy
Roy Raines—Prudential Life Ins. No. 1	22-10N- 9W	1,205	Wilcox
RED RIVER PARISH			
Ark. Fuel Oil Co.—Franklin Realty Co. No. 1	20-11N- 9W	7,155	Travis Peak

TABLE I—*Continued*

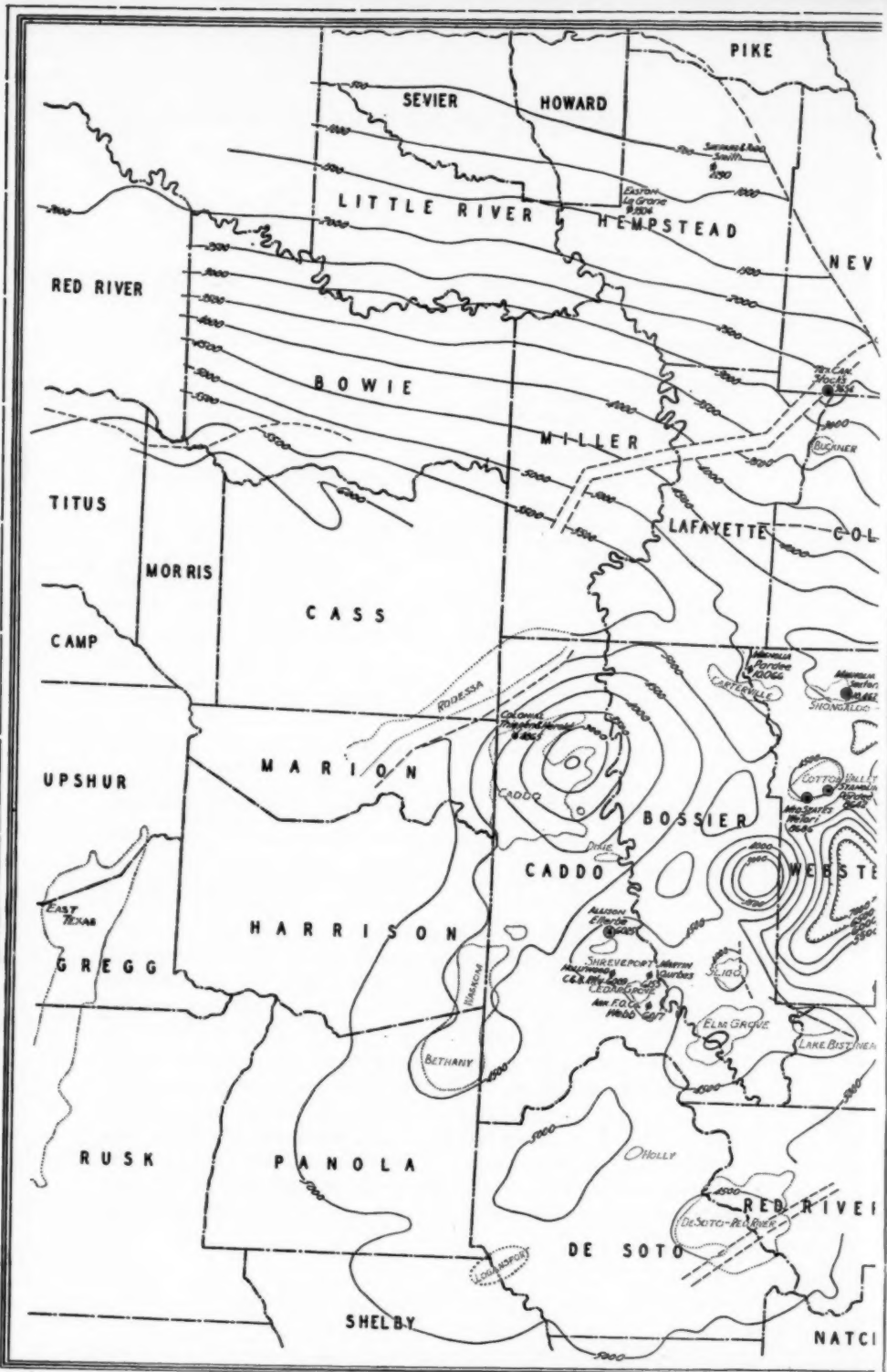
Company and Farm	*Section, Township, Range*	*Feet Total Depth*	*Bottom of Hole in*
J. M. Fergotson *et al.*—J. G. Marston No. 1	30-14N-10W	1,713	Ozan
Glassell & Whitehurst—LeLong No. 1	25-12N-11W	2,874	Paluxy
N. W. Hunter—LeLong No. 1	33-12N-10W	2,868	Paluxy
Magnolia Pet. Co.—J. C. Pugh No. 59	12-12N-11W	6,487	Lower Glen Rose
H. D. Rodgers—Long Bell Lbr. No. 3	30-13N- 9W	1,623	Annona chalk
SABINE PARISH			
W. L. McClanahan—Frost Lbr. Co. No. 1	22- 9N-13W	5,710	Lower Glen Rose
Albert Reich—Giague No. 1	27- 7N-14W	4,342	Paluxy
Republic Gas Co.—Whitney Corp. No. 1	8- 9N-13W	8,929	Travis Peak
Sutton-Zwolle O. Co.—Sabine Lbr. Co. No. 1	23- 7N-14W	4,208	Paluxy
Zwolle Syndicate—Mansfield Lbr. Co. No. 1	8- 7N-14W	4,323	Paluxy
UNION PARISH			
Joe Modisette and Standard Oil Co.—Frost Lbr. Co. No. 1	14-21N- 1E	9,983	Smackover limestone
WEBSTER PARISH			
Midstates O. Co.—Welori Lbr. Co. No. 1	3-20N-10W	8,686	Cotton Valley
Magnolia Pet. Co.—Sexton Unit No. 1	32-23N- 9W	10,462	Cotton Valley or older
A. G. Oliphant—D. W. & E. L. Stewart No. B-1	5-20N-10W	9,187	Cotton Valley
Sibley-Sabine Corp.—W. M. McDonald No. 1	32-17N- 9W	6,297	Lower Glen Rose
Stanolind O. & G. Co.—Pardee Lbr. Co. No. 1	36-21N-10W	8,642	Cotton Valley
ARKANSAS			
BRADLEY COUNTY			
Phillips Pet. Co.—Marsden No. 1	9-16S-11W	5,143	Smackover limestone
CALHOUN COUNTY			
S. S. Alexander—L. Smythe No. 1	7-11S-14W	3,406	Eagle Mills
CLEVELAND COUNTY			
W. E. Allum, Tr.—Moore Est. No. 1	34- 9S-10W	3,821	Ozan?
J. T. Marwick & E. O. Olds—Aubry Vance No. 1	18-11S-11W	3,561	Tokio
COLUMBIA COUNTY			
Robert Keene *et al.*—Runyon Est. No. 1	1-16S-21W	1,008	Basal Wilcox
Kerr-Lynn Oil Co.—Barnett No. 1	14-17S-20W	7,730	Smackover limestone
E. O. Olds—M. Dennis No. 1	4-17S-21W	4,513	Lower Glen Rose
Standard Oil Co.—W. P. Phillips No. 1	15-17S-19W	7,603	Smackover limestone
Tidewater-Seaboard O. Co.—Beene No. 1	15-18S-19W	8,332	Smackover limestone
CRITTENDEN COUNTY			
Manning & Martin—Cartwright No. 1	16- 7N- 8E	4,208	Ordovician
Stanley O. Corp.—Danner No. 1	18- 8N- 9E	3,351	Paleozoic
DALLAS COUNTY			
L. S. Gist—J. H. Goodgame No. 1	26-10S-16W	2,097	Brownstown?
DESHA COUNTY			
Columbian Fuel Corp.—V. Cross No. 1	34- 8S- 3W	4,915	Igneous

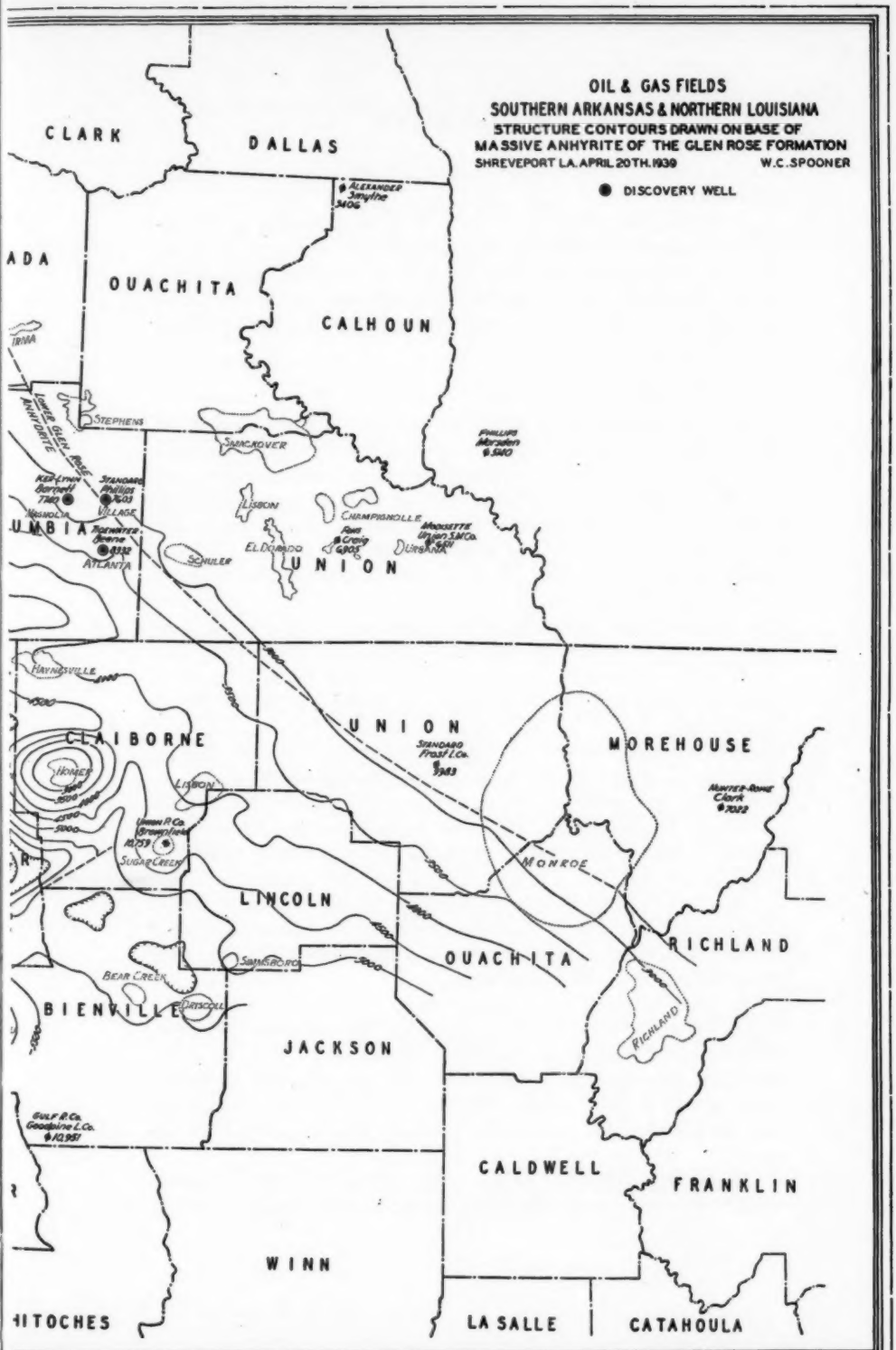
TABLE I—*Continued*

Company and Farm	*Section, Township, Range*	*Feet Total Depth*	*Bottom of Hole in*
HEMPSTEAD COUNTY			
H. D. Easton *et al.*—R. M. LaGrone No. 1	5-12S-26W	3,511	Eagle Mills
Sheppard-Todd—Smith No. 1	1-11S-24W	2,290	Eagle Mills
LITTLE RIVER COUNTY			
Fred Smith—W. D. Waldrop No. 1	4-13S-31W	3,431	Basal Travis Peak
LONOKE COUNTY			
Cabot Drlg. Club—Deason No. 1	18- 4N- 9W	2,760	Paleozoic
Frank Silver—Chambers No. 1	17- 2N- 2W	1,644	Paleozoic
Frank Silver—Chambers No. 2	17- 2N- 2W	1,500	Paleozoic
MILLER COUNTY			
Hill & Easterbrook—Sherman No. 1	29-19S-28W	6,330	Lower Glen Rose
NEVADA COUNTY			
J. E. Speer, Tr.—Phillips No. 1	18-14S-21W	1,476	Arkadelphia
Tex. Canadian O. Co.—Stocks No. 1	9-15S-22W	3,654	Travis Peak
Union Drlg. Co.—Fuller No. 1	5-13S-21W	1,433	Nacatoch
OUACHITA COUNTY			
Copenhaver O. Corp.—J. E. Evans No. 1	20-11S-19W	1,825	Travis Peak
A. H. Tarver *et al.*—J. S. Dean Est. No. 1	16-14S-19W	2,225	Tokio
A. H. Tarver *et al.*—Mrs. Guy Smith No. 1	16-14S-19W	2,330	Tokio
PULASKI COUNTY			
A. L. Kitzelman *et al.*-Fee No. 2	2- 1S-13W	4,080	Paleozoic
Ozark Nat. Gas Co.—Shropshire No. 1	21- 8N-29W	2,740	Pennsylvanian
PIKE COUNTY			
Bruce E. Wallace *et al.*—Tilyeu No. 1	26- 8S-24W	404? 610?	Paleozoic
UNION COUNTY			
Fohs Oil Co.—Craig No. 1	5-18S-14W	6,905	Smackover lime-stone
Joe Modisette *et al.*—Union Saw Mill No. 2	8-18S-12W	6,511	Smackover lime-stone
E. G. Bradham—S. L. Robbins No. 1	12-19S-16W	2,300	Nacatoch
Suggs *et al.*—Jerry No. 1	28-17S-14W	3,480	Travis Peak

of oil was found in the "D" sand and the Bodcaw sand. The discovery wells were the Midstates Oil Company's Welori Lumber Company No. 1, Sec. 3, T. 20 N., R. 10 W., in the "D" sand; and the Stanolind Oil and Gas Company's Pardee No. 1, Sec. 36, T. 21 N., R. 10 W., in the Bodcaw sand. The oil in these sands apparently is limited to a narrow band along the margin of the producing area.

In the Shongaloo field, the Magnolia Petroleum Company's Sexton No. 1, Sec. 32, T. 23 N., R. 9 W., was completed as a gas and distillate well at a depth of 8,990 feet. The producing zone in the Sexton well is a sand in the lower part of the Cotton Valley formation. The Sexton No. 1 was drilled to a total depth of 10,462 feet and plugged back to the producing depth. Considering the depth, the thickness,


PIKE
SEVIER
HOWARD
LITTLE RIVER
HEMPSTEAD
NEV
RED RIVER
BOWIE
MILLER
TITUS
LAFAYETTE
COL
MORRIS
CASS
CAMP
MARION
UPSHUR
CADDO
BOSSIER
CADDO
WEBSTE
HARRISON
EAST TEXAS
GREGG
BETHANY
RUSK
PANOLA
HOLLY
RED RIVE
DE SOTO
SHELBY
NATCI


OIL & GAS FIELDS
SOUTHERN ARKANSAS & NORTHERN LOUISIANA
STRUCTURE CONTOURS DRAWN ON BASE OF
MASSIVE ANHYRITE OF THE GLEN ROSE FORMATION
SHREVEPORT LA. APRIL 20TH. 1939 W.C. SPOONER
DISCOVERY WELL
CLARK
DALLAS
OUACHITA
CALHOUN
UNION
CLAIBORNE
MOREHOUSE
LINCOLN
RICHLAND
BIENVILLE
JACKSON
CALDWELL
FRANKLIN
WINN
LA SALLE
CATAHOULA
STEPHENS
LISBON
SMACKOVER
EL DORADO
ATLANTA
SCHULER
HAYNESVILLE
HOMER
SUGAR CREEK
BEAR CREEK
DRISCOLL
MONROE
RICHLAND

and the porosity of the producing sand, this discovery is not of major importance.

In the Sugar Creek field, T. 19 N., R. 5 W., Claiborne Parish, the Union Producing Company's Brownfield No. 2, in Sec. 5, T. 19 N., R. 5 W., was drilled to a total depth of 10,759 feet where it was junked. This well had gas- and distillate-bearing sand in the Cotton Valley formation which, however, was less porous than the equivalent sands in the Cotton Valley field.

IMPORTANT DRY HOLES DRILLED DURING 1938

The present knowledge of the stratigraphy indicates that future production of oil and gas from this region will be obtained principally from the Cotton Valley formation and from the Smackover limestone.

The Cotton Valley formation consists of shale and interbedded sand. The Smackover limestone is made up of an upper porous and oölitic member—the oil- and gas-producing member—and a lower dense non-porous member. Both of these formations have shown marked lateral lithologic variations which determine in large part their suitability as reservoirs for oil and gas accumulation. For these reasons several of the deep dry holes drilled during the year were important in that they helped in defining the area in which favorable reservoir conditions can be expected to be present in the deeper formations.

The Modisette *et al.* Frost Lumber Company No. 1, in Sec. 14, T. 21 N., R. 1 E., Union Parish, Louisiana, and the Hunter-Rowe *et al.* Clark No. 1, in Sec. 10, T. 20 N., R. 7 E., Morehouse Parish, Louisiana, penetrated the Smackover limestone. The Cotton Valley formation and the Smackover limestone were generally lacking in porosity.

The Gulf Refining Company's Goodpine Lumber Company No. 1, in Sec. 25, T. 14 N., R. 8 W., Bienville Parish, Louisiana, penetrated most of the Cotton Valley formation and encountered only thin hard dense sandstone in this formation.

In the Shreveport area the Arkansas Louisiana Gas Company's Webb No. 1, in Sec. 4, T. 16 N., R. 14 W., the Hollywood Oil Company's C and B Realty Company No. 1, in Sec. 22, T. 17 N., R. 14 W., and F. W. Martin's Querbes No. 1, in Sec. 37, T. 17 N., R. 13 W., failed to find porosity in the lower part of the Glen Rose formation and thus limited the production from the Shreveport field on the south.

In Madison Parish, Louisiana, the Continental Oil Company drilled two wells on an interior salt dome, both dry holes.

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VOL. 23, NO. 6 (JUNE, 1939), PP. 903-931, 7 FIGS.

DEVELOPMENTS IN ROCKY MOUNTAIN REGION IN 1938[1]

J. M. KIRBY[2] AND H. N. HICKEY[3]
Denver, Colorado

ABSTRACT

Drilling operations of all descriptions in the Rocky Mountain Region during 1938 reached a total of 483, divided as follows.

WILDCAT WELLS					FIELD WELLS					
1938 Completions				Drlg.	1938 Completions				Drlg.	
Oil	*Gas*	*Ab'd.*	*Susp.*	*1/1/39*	*Oil*	*Gas*	*Ab'd.*	*Susp.*	*1/1/39*	*Total*
5	3	43	61	48	156	34	52	33	48	483

Discovery of new oil fields includes Cole Creek, Natrona County, Wyoming; Wilson Creek, Rio Blanco County, Colorado; North Cut Bank, Glacier County, Montana; Big Hollow, Albany County, Wyoming; and Shoshone, Park County, Wyoming. The last is a black-oil discovery, and, coupled with the field extension at Hamilton Dome, Hot Springs County, Wyoming, promises to add materially to the black-oil reserves of Wyoming. The shallow discovery at Big Hollow is of low gravity, and of probable minor significance. The North Cut Bank discovery is the first Moulton sand (Kootanai—Lower Cretaceous) oil producer, although several gas wells have been completed in this zone.

Extensions of other proved fields were accomplished at West Kevin, Toole County, Montana, and at Lance Creek, Niobrara County, Wyoming. The eighteen Leo sand (Minnelusa) completions at Lance Creek during 1938 indicate that the ultimate productive area from this zone may reach 5,500 acres, with a gross recovery approaching 47,500,000 barrels.

Deepening or recompleting wells in proved fields resulted in a Tensleep discovery for Mahoney Dome, Carbon County, Wyoming, and in a small oil well from shallow Wasatch sands at Hiawatha, Moffat County, Colorado. Mahoney Dome had previously produced natural gas commercially from the Dakota and Sundance sands, and Hiawatha, gas from shallow Wasatch sands.

New gas fields resulted during 1938 from drilling at Beaver Creek, Fremont County, Wyoming; at Oil Springs, Carbon County, Wyoming; and in Sec. 30, T. 37 N., R. 4 W., Glacier County, Montana. The last discovery is 4 miles north of the main Cut Bank gas area, and produces from the Moulton sand. The gas at Beaver Creek was found in a sand of the Morrison formation; and, at Oil Springs, in the Lakota and First and Second Sundance sands. Extension of the Muskrat gas field, Fremont County, Wyoming, and of the Clay Basin gas field, Daggett County, Utah, was also accomplished by 1938 drilling.

The gross production of oil in the Rocky Mountain region (exclusive of southeastern New Mexico) for 1938, is estimated at 25,450,205 barrels, as compared with 27,397,660 barrels in 1937.

INTRODUCTION[4]

The Rocky Mountain Region, during the year 1938, was the scene of only moderate activity, total operations of all descriptions following

[1] Read before the Association at Oklahoma City, March 23, 1939, with the permission of The California Company. Manuscript received, April 17, 1939.

[2] District geologist, The California Company.

[3] Geologist, The California Company.

[4] Appreciation is expressed to Earl Shoenfelt of Petroleum Information, Inc., Denver, Colorado. All structural contour maps shown herein are reprinted from Petroleum Information, Inc., *Résumé-Rocky Mountain Oil and Gas Operations for 1938.*

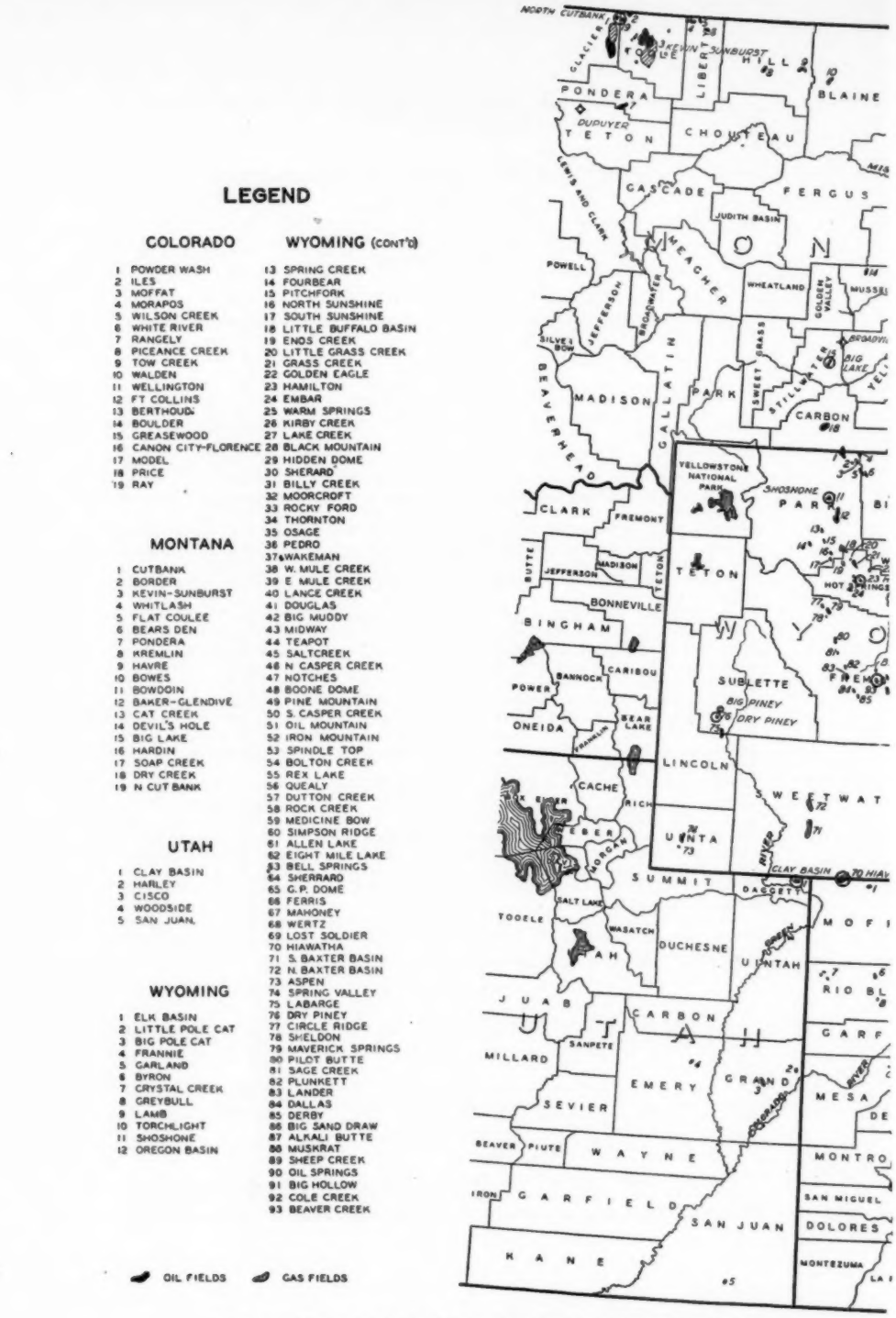

FIG. 1.—Oil and gas fields of parts of Rocky Mountain and High Plains regions, showing areas of important developments during 1938. (Courtesy, E. H. Hunt, The Texas Company, Denver, Colorado.)

DANIELS
SHERIDAN
DIVIDE
BURKE
BOTTINEAU
PHILLIPS
VALLEY
ROOSEVELT
WILLIAMS
NESSON
MOUNTRAIL
WARD
MC HENRY
RICHLAND
MC KENZIE
MC LEAN
MC CONE
DUNN
MERCER
GARFIELD
DAWSON
OLIVER
PRAIRIE
BILLINGS
STARK
MORTON
BURLEIGH
SLOPE
HETTINGER
GRANT
CUSTER
FALLON
BOWMAN
ADAMS
CORSON
BIG HORN
CARTER
HARDING
PERKINS
DEWEY
SHERIDAN
BUTTE
ZIEBACH
CROOK
MEADE
HAAKON
STANLEY
JOHNSON
CAMPBELL
PENNINGTON
JACKSON
JONES
WESTON
CUSTER
WASHINGTON
WASHABAUGH
MELLETTE
FALL RIVER
SHANNON
BENNETT
TODD
NIOBRARA
COLE CREEK
CONVERSE
LANCE CREEK
DAWES
CHERRY
SIOUX
AGATE
BOX BUTTE
SANDHILL
GRANT
HOOKER
THOMAS
OIL SPRINGS
PLATTE
GOSHEN
MEDICINE
ALBANY
BOW
GARDEN
ARTHUR
MC PHERSON
LOGAN
BANNER
MORRILL
LARAMIE
HOLLOW
KIMBALL
CHEYENNE
DEUEL
KEITH
LINCOLN
PERKINS
JACKSON
LARIMER
WELD
LOGAN
SEDGWICK
PHILLIPS
CHASE
HAYES
ROUTT
GRAND
BOULDER
MORGAN
YUMA
DUNDY
HITCHCOCK
WILSON CREEK
ADAMS
WASHINGTON
EAGLE
ARAPAHOE
PITKIN
LAKE
DOUGLAS
ELBERT
RAMAH
KIT CARSON
PARK
TELLER
EL PASO
LINCOLN
GULF-LARSEN
CHEYENNE
GUNNISON
CHAFFEE
FREMONT
ARKANSAS
CROWLEY
KIOWA
COTTONWOOD
SAGUACHE
CUSTER
PUEBLO
OTERO
BENT
PROWERS
HINSDALE
MINERAL
RIO GRANDE
ALAMOSA
HUERFANO
ARCHULETA
CONEJOS
COSTILLA
LAS ANIMAS
BACA

the general downward trend noted in the operations for 1937. The end of 1938, however, records approximately one hundred wildcat wells and eighty-one field wells drilling or suspended for various reasons, a situation which promises some increase in activity, and perhaps a more normal tone for the petroleum industry in this region for 1939. At this point, it may be stated that these totals include wells of all degrees of promise and ultimate prospective depth, drilled primarily for the purpose of oil production. We may assume that a notable percentage of the suspended wells will never resume operations, or will be abandoned at their present depth. However, their actual operations during 1938 have added to the total operations recorded for this period.

Developments of most importance for this region during the year include (1) the discovery of commercial oil production in the Lakota sand on the Cole Creek structure, Natrona County, Wyoming; (2) the discovery of Morrison sand (Jurassic?) production on the Wilson Creek structure, Rio Blanco County, Colorado;[5] (3) the extension of the Minnelusa sand (Pennsylvanian) productive area in the Lance Creek field, Niobrara County, Wyoming; (4) the confirmation of profitable Tensleep sand (Pennsylvanian) oil production in the old Mahoney gas field, Carbon County, Wyoming, as suggested by a test drilled in 1930; (5) the extension of black-oil producing acreage at Shoshone, Park County, Wyoming, and at Hamilton Dome, Hot Springs County, Wyoming; (6) the discovery of new natural gas reserves on Beaver Creek structure, Fremont County, Wyoming; at Oil Springs, Carbon County, Wyoming; and north of the main Cut Bank gas area, Glacier County, Montana; and (7) the development of the first Moulton sand (Kootenai—Lower Cretaceous) oil production at North Cut Bank, Glacier County, Montana.

NEW OIL FIELDS DISCOVERED DURING 1938

COLORADO

Wilson Creek.—The discovery well for this field was drilled jointly by The Texas Company and The California Company, in Sec. 35, T. 3 N., R. 94 W., Rio Blanco County, Colorado. The producing sandstone, lying near the base of the Morrison formation, was encountered at a depth of 6,664–6,693 feet; and, on a 24-hour test through 2½-inch tubing, and using a ⅝-inch bean, the well produced

[5] This discovery was recorded by Edwin H. Hunt, in "Developments in Rocky Mountain Region in 1937," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 22, No. 6 (June, 1938). The initial formation tests indicating the presence of commercial oil production from the Morrison sand took place on December 19, 1937. Final completion occurred, February 15, 1938. The discovery may logically be attributed to 1938.

253 barrels of 48° A.P.I. gravity, paraffine base oil, together with approximately 230 thousand cubic feet of gas.

This well was drilled to a total depth of 6,918 feet, logging the top of the Sundance formation at 6,787 feet, and the top of the Sundance sand (Nugget?) at 6,824 feet. Cores from this sand showed streaked saturation throughout a rather thick zone, but formation tests conducted at various intervals in the sand section showed only water.

The Wilson Creek structure is a large dome developed along the Danforth Hills line of folding, and shows approximately 900 feet of surface closure, embracing some 15,000 acres. Two wells had previously been drilled on this structure, in Sec. 27, T. 3 N., R. 94 W., one of which reached and tested the sandstones of the Dakota group. This test, as well as the discovery well, found the Dakota sandstones water-bearing.

With only one producing well completed up to the time of this writing, it is impossible to estimate the areal extent of the Morrison sand production, or to arrive at any satisfactory estimate of the ultimate yield.

MONTANA

North Cut Bank.—In the SE. ¼, SW. ¼ of Sec. 23, T. 37 N., R. 5 W., Glacier County, Montana, the Yukon Oil Company's Lundgren No. 1 has apparently discovered commercial production in the Moulton sand, at a depth of 2,549 feet. This well is reported to have swabbed 175 barrels per day, and, more recently, to be flowing at an 80-barrel-per-day rate.

The location of this test is about 6 miles southwest of the Border oil field and approximately 12 miles northeast of the north end of the Cut Bank oil field, and is about ¾ mile south of the Yukon Oil Company's Jacobson No. 1, center of NW. ¼, NW. ¼ of Sec. 23, T. 37 N., R. 5 W., which was completed several years ago as a Cut Bank sand well, and which reported nothing in the Moulton sand at this location.

The sand in question has never produced oil in this area, but has yielded gas commercially in five or six wells in the main Cut Bank gas field. Consequently, the significance of this oil discovery is not known at this time. It is believed, however, that the area of production may be small, because of the general lenticularity of the Moulton sand.

Since the discovery well was completed, a southwest diagonal offset, the Yukon Oil Company's Lundgren No. 2, center of NE. ¼, NW. ¼ of Sec. 26, T. 37 N., R. 5 W., has been abandoned at 2,735 feet, total depth. The Moulton sand contained a small quantity of oil and

gas and the Sunburst sand contained water. This failure probably indicates the erratic nature of oil saturation in the Moulton sand.

WYOMING

Big Hollow.—On the Big Hollow structure, in the SW. ¼, SE. ¼ of Sec. 6, T. 15 N., R. 75 W., Albany County, Wyoming, G. R. McConnell has completed a shallow Muddy(?) sand well, at 890–920 feet. An initial production of 25 barrels of black oil, of approximately 21° gravity has been reported, but no large quantity of oil has been produced or marketed to date. Several wells in this section have reported encouraging showings in the Harris sand, but the poor quality of the oil and the indicated low potentials of the earlier wells had previously discouraged any serious attempts to complete or produce the wells. Consequently, the importance of this discovery is not known at this time.

Cole Creek.—The Cole Creek oil field was discovered in May, 1938, by completion of the General Petroleum Corporation's Government No. 1, center of NW. ¼, SE. ¼ of Sec. 21, T. 35 N., R. 77 W., Natrona County, Wyoming. This well was drilled to a total depth of 8,019 feet, and was completed as a Lakota sand well from saturation occurring at 7,974–8,016 feet. Attempts to make the well flow were unsuccessful, and it was finally completed pumping at a rate of approximately 10 barrels per hour. At the end of a 7-day test, production reached a maximum of 336 barrels of oil in 24 hours. The oil has an A. P. I. gravity of 32.7°, testing 21.4 per cent gasoline and naphtha.

During the progress of drilling, some saturation had been noted in the Shannon sand, at 4,509–4,543 feet. Formation tests on this interval before final completion of the well showed this sand to be water-bearing. The First Wall Creek sand was encountered at 6,686 feet, with saturation in varying degrees reported between 6,686 and 6,860 feet. Formation tests on this sand in the interval 6,748–6,840 feet were not commercial because of the fine, tight nature of the sand.

Other formation markers reported in this well are as follows.

	Feet
Second Wall Creek sand	7,051–7,125
Third Wall Creek sand	7,294–7,309
Muddy sand	7,779–7,788
Dakota sand	7,914–
Lakota sand	7,974–8,013
Morrison formation	8,013–8,020, total depth

The area of probable production at Cole Creek is not known at this time, inasmuch as only one producing well has been completed. The structure, as expressed at the surface, is rather indefinite; and the

extent of the structure, as revealed by geophysical methods, has not yet been published.

At the date of this writing, the General Petroleum Corporation has abandoned its second well, State No. 1, NW. ¼, NE. ¼, SE. ¼ of Sec. 16, T. 35 N., R. 77 W., at a total depth of 8,707 feet. The well bottomed in red beds of the Chugwater formation, top of which is placed at 8,706 feet. The Lakota sand, productive in the discovery well, was hard and tight. Sands in the Sundance section between 8,370 and 8,706 feet were well developed but barren. The failure of this well in the Lakota sand may be attributed possibly as much to unfavorable sand conditions as to the fact that it was approximately 130 feet lower, structurally, than the discovery well. The discovery well is now being deepened to test the Sundance sands.

EXTENSIONS TO OLD OIL-PRODUCING AREAS

MONTANA

Kevin-Sunburst.—During 1938, continued drilling in the western part of the old Kevin-Sunburst field expanded the proved and semi-proved area into the southwestern corner of T. 35 N., R. 3 W. The greater part of the drilling resulting in more profitable wells was seemingly concentrated in the Gunderson area, centering in Sec. 19, T. 35 N., R. 2 W. The majority of the limestone wells completed during the year were treated with acid, a practice which has resulted in a general increase in potential production.

Completions in the Kevin-Sunburst area totaled 53, as compared with 107 in 1937 and 73 in 1936. Thirty-six of these completions were oil wells, two were gas wells, and fifteen were dry holes. The combined initial production of the 36 oil wells is approximately 1,600 barrels daily, and of the two gas wells, approximately 4 million cubic feet daily.

WYOMING

Hamilton Dome.—The producing area of the Hamilton Dome field, in Hot Springs County, Wyoming, was extended ¾ mile northwest in 1937, by the completion of the Italo Petroleum Corporation's Phebus-Government No. 1, NW. ¼, NW. ¼, SW. ¼ of Sec 11, T. 44 N., R. 98 W., reportedly producing 250 barrels per day, initially, from the Tensleep sand. During December, 1938, the proved limits of the field were extended northeast by the same company.

The well extending the northeastern proved producing area at Hamilton Dome is the Italo Petroleum Corporation's Skelton-Government No. 1, located in the SW. ¼, SE. ¼, NE. ¼ of Sec. 13, T. 44 N., R. 98 W. This well had an initial production of 73 barrels

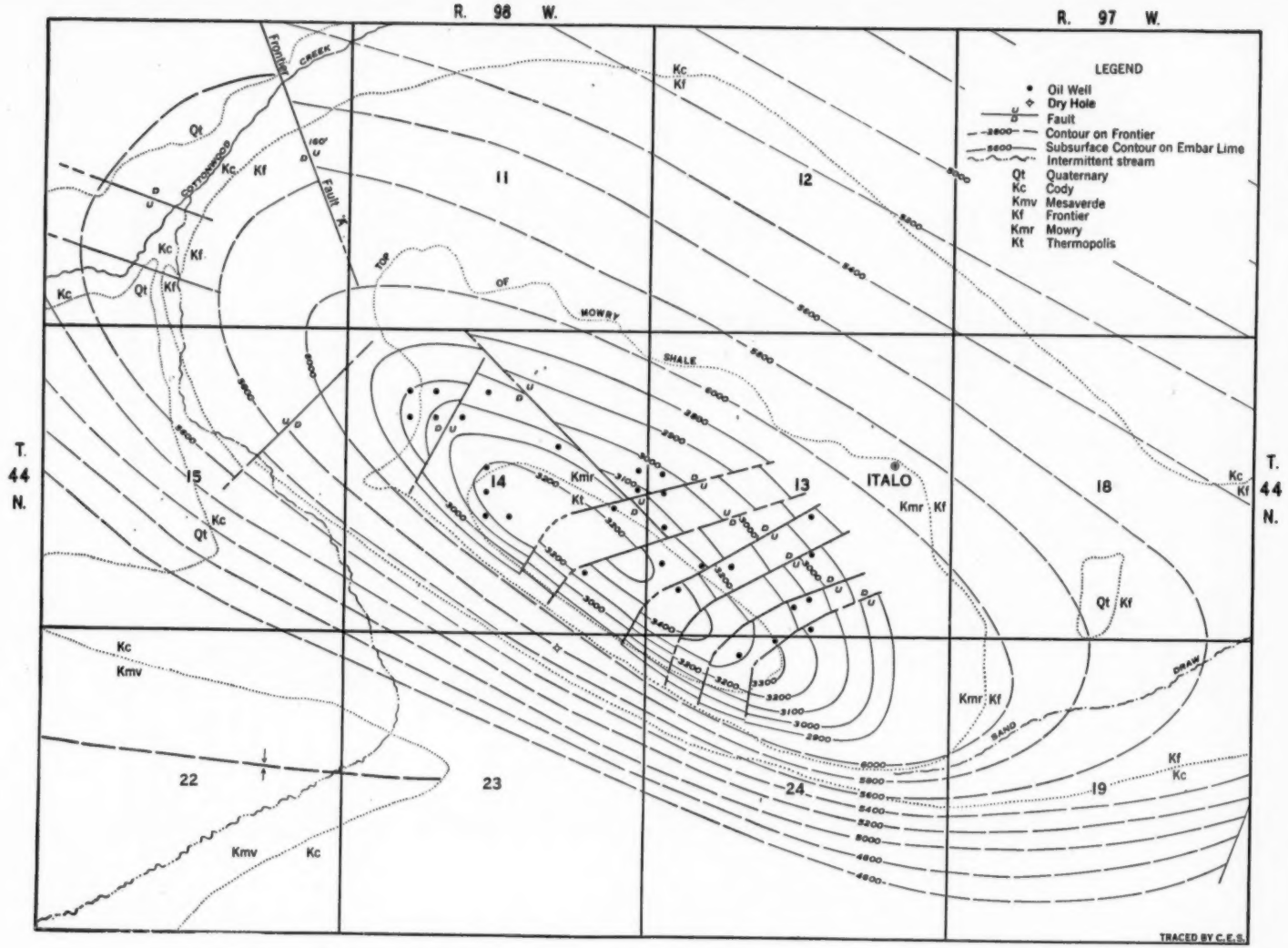

FIG. 2.—Structural contour map of Hamilton Dome, Hot Springs County, Wyoming. Geology after Clayton Phebus.

per day on the pump, from the Embar limestone at 2,875–2,901 feet. The top of the Sundance sand was logged at 1,434 feet, the top of the Chugwater red beds at 1,512 feet, and the top of the Embar limestone at 2,820 feet, with saturation occurring below 2,875 feet.

At present, Hamilton Dome produces black oil of 19° gravity from the Chugwater red beds, and oil of 26.3° gravity from the Embar limestone. The Tensleep sand in this field has not been seriously exploited, primarily because of the limited market for black oil.

Lance Creek.—The vigorous development of the newly discovered Leo sand (Pennsylvanian) pay in the Lance Creek field, which began in 1937, was continued unabated during 1938. Extension of the Leo sand producing area on the southwest and south amounted to several hundred acres. Current estimates of the Leo producing area, as defined by drilling during 1938, vary from 5,200 to 5,500 acres, with ultimate recovery from this zone approaching 47,500,000 barrels.

The western limit of Leo sand production was determined during 1938, by the failure of J. E. Manning's Pecklow No. 1, SE. ¼, SE. ¼, SE. ¼ of Sec. 1, T. 35 N., R. 66 W. The eastern limit had been previously determined by the failure of the Ohio Oil Company's No. 1 on Leo No. 7, NW. ¼, NW. ¼, SE. ¼ of Sec. 35, T. 35 N., R. 65 W., two locations east of the Ohio Oil Company's No. 6 on Leo No. 16, completed early in 1939 producing 2,240 barrels per day.

Sundance completions for 1938 added little acreage to the original estimated limits of Sundance production. Current estimates of the ultimate productive acreage from Sundance sands is placed at 2,285 acres. Of this figure, 2,195 acres are included within the present unitized area. This estimate of productive area is now subject to some revision, however, because of the plugging and recompletion during March, 1939, of the Ohio Oil Company's No. 1 on Leo No. 7, with a reported initial production of 190 barrels per day from the basal Sundance sand. This location is about one mile east of any Sundance sand production, and its significance is unknown at present. It had previously pumped a few barrels per day from the top of the Leo sand zone, and, on deepening, had found water in the lower part of the sand.

Shoshone anticline.—The Shoshone anticline, Park County, Wyoming, was the scene of numerous shallow tests to the Muddy sandstone prior to 1924, which resulted in small pumping wells. Subsequent deeper drilling resulted in some showings of oil in the Greybull sand, but it was not until 1929 that the Ohio Oil Company tested the Embar limestone in the NW. ¼, NW. ¼ of Sec. 27, T. 53 N., R. 101 W., securing an initial production of 45 barrels of oil per day at 4,752–4,765 feet.

FIG. 2.—Structural contour map of Hamilton Dome, Hot Springs County, Wyoming. Geology after Clayton Phebus.

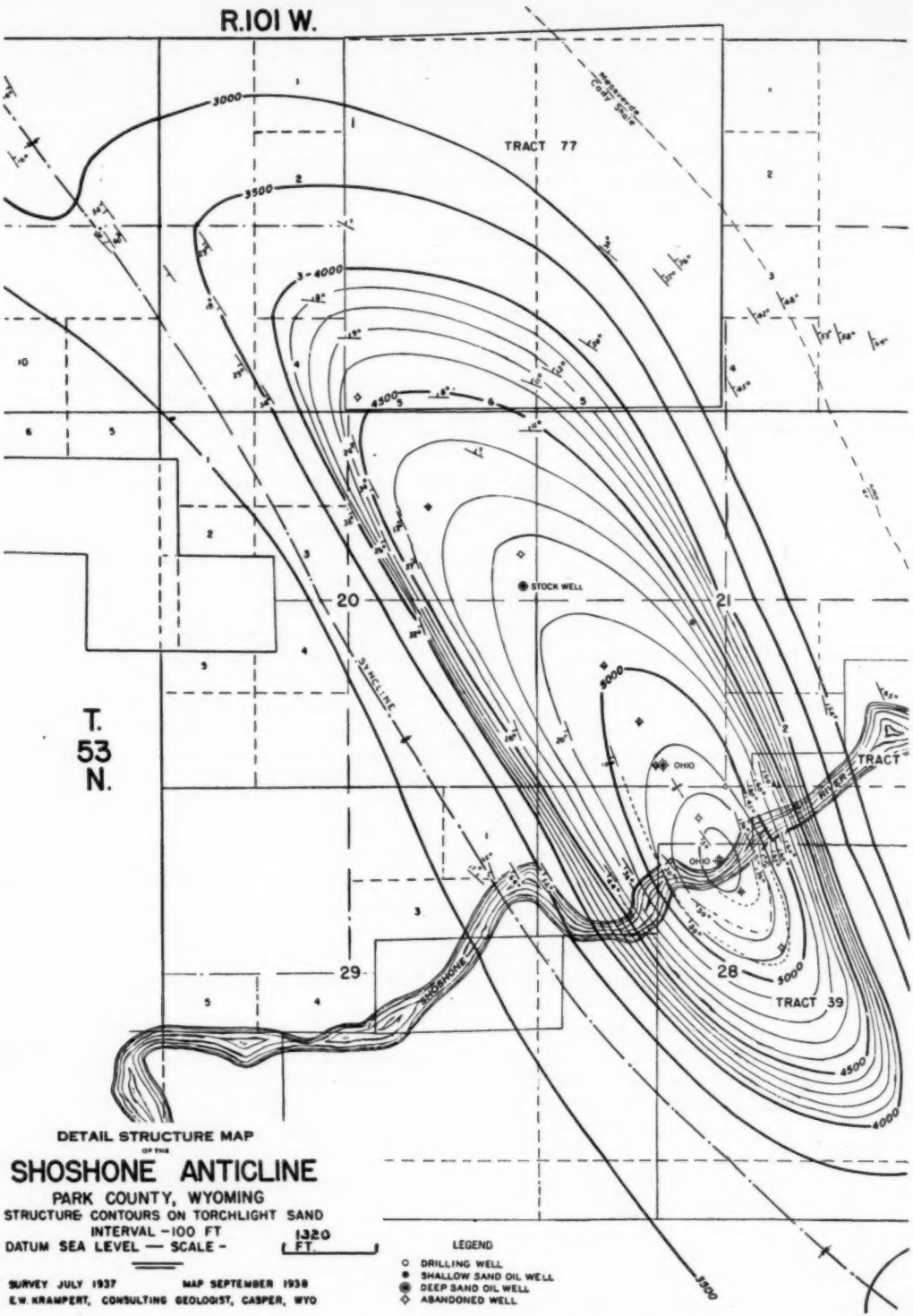

FIG. 3.—Structural contour map of Shoshone anticline, Park County, Wyoming.

In July, 1938, Paul Stock completed Bertha Rousseau No. 1, SE. ¼, SE. ¼, NE. ¼ of Sec. 20, T. 53 N., R. 101 W., in the Embar limestone, at a total depth of 4,809 feet. This well flowed at the rate of 10 barrels of oil per hour, after acid. Although this completion can not be construed as a new discovery, it constitutes an important extention of the old Shoshone producing area, and promises to add materially to the black-oil reserves of Wyoming.

The Shoshone structure is an elongate anticlinal fold, traceable for approximately 4 miles at the surface. The closure is estimated at 1,800 feet, embracing 1,500 acres within the lowest closing contour.

DISCOVERIES OF OIL RESULTING FROM DEEPENING OR RECOMPLETING WELLS IN OLD FIELDS

COLORADO

Hiawatha.—The Hiawatha structure, located in T. 12 N., R. 100 W., Moffat County, Colorado, has been a consistent producer of natural gas in marketable quantities from the Wasatch formation of Eocene age. The Wasatch gas-bearing members occur as irregular sandstone lenses at depths ranging from 1,950 to 2,800 feet.

The presence of oil in small quantities in similar sand lenses of the Wasatch formation has been known for a number of years, and certain wells tested these sands for oil production in the early days of the field, without particularly encouraging results. No serious effort to develop oil production was made until October, 1938, when the Mountain Fuel Supply Company gun-perforated the casing in its old Kuykendall No. 1, NE. ¼, NE. ¼, SE. ¼ of Sec. 22, T. 12 N., R. 100 W., between 2,472 and 2,483 feet. After a bailing and swabbing test, the well was placed on the pump. Over a 60-day period, the well is reported to have produced an average of 80 barrels per day of 47° A. P. I. gravity oil.

In all probability, a small oil field at Hiawatha will result from experimental recompletions begun in 1938. However, sufficient wells have been drilled in this area to indicate that it will not be of major importance.

WYOMING

Mahoney Dome.—For many years, Mahoney Dome, Carbon County, Wyoming, has produced gas in commercial amounts from the Dakota and Sundance sands. A Tensleep sand test, drilled jointly by the Producers and Refiners Corporation and the Midwest Refining Company in the SE. ¼, NW. ¼ of Sec. 34, T. 26 N., R. 88 W., was completed in 1930 with an estimated production of 75 barrels per day of 32° A. P. I. oil, at 4,660–4,682 feet, after plugging back from a depth

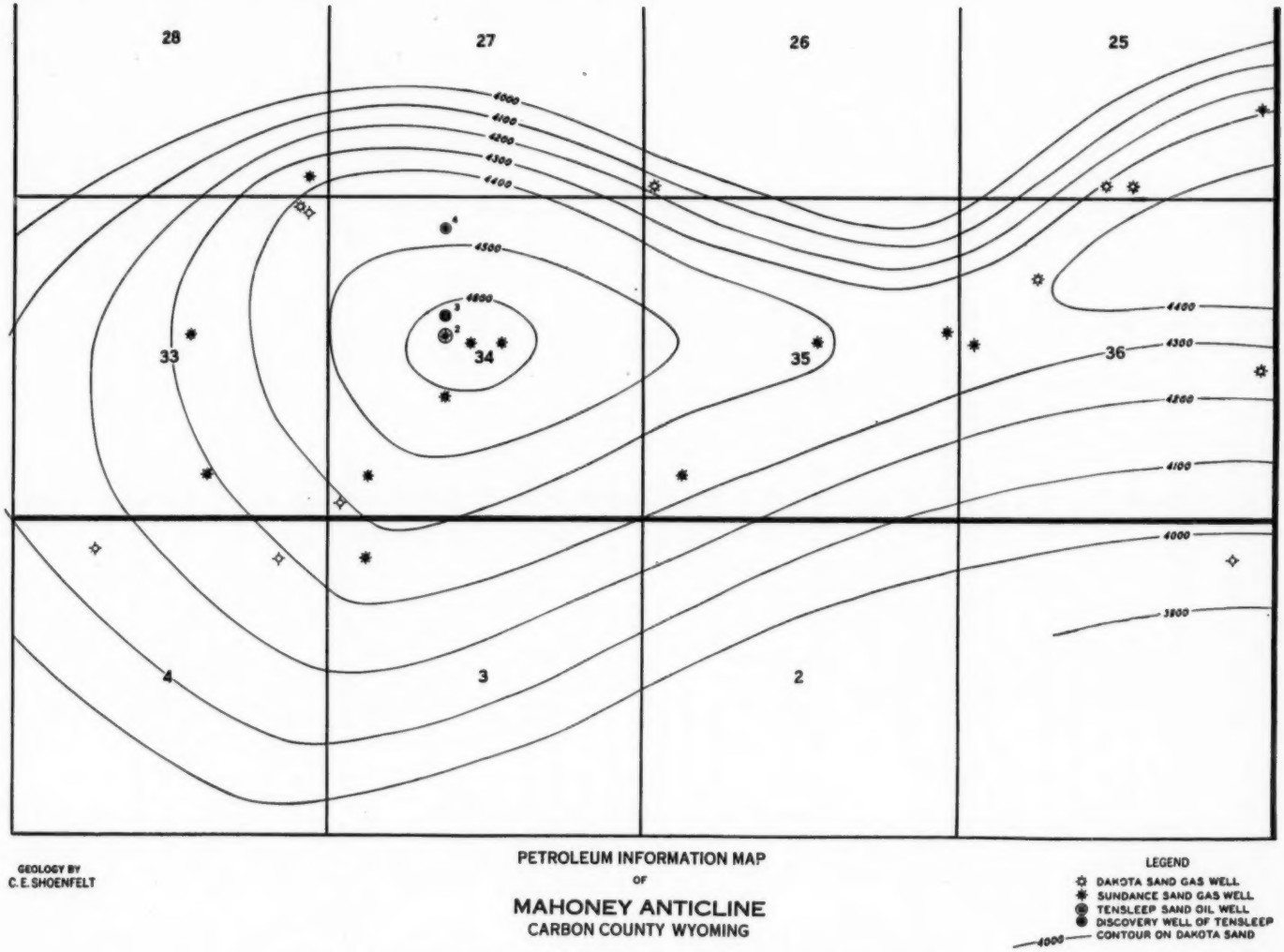

FIG. 4.—Structural contour map of Mahoney anticline, Carbon County, Wyoming.

of 4,760 feet. The potentialities of the Tensleep sand were apparently not recognized at that time, because of a very crooked hole, in poor condition for satisfactory completion.

In October, 1938, the Sinclair-Wyoming Oil Company completed its No. 3-F well, located in the center of NW. ¼, NW. ¼ of Sec. 34, T. 26 N., R. 88 W., in the Tensleep sand at 4,295–4,486 feet, total depth. This well established a potential of 635 barrels per day, flowing through the casing, and was ultimately completed through tubing at 172 barrels per day. The completion of this well serves to establish the Tensleep sand on the Mahoney structure as an important source of oil production.

Since the completion of its initial well, the Sinclair-Wyoming Oil Company has placed a second well on production, in the center of NE. ¼, SW. ¼ of Sec. 34, T. 26 N., R. 88 W., which swabbed 198 barrels of oil in 24 hours, and was completed flowing 30 barrels of oil per day. The area of saturation in the Tensleep sand can not be estimated at this stage of development.

Mahoney Dome is at the west end of the Mahoney-Ferris trend, in T. 26 N., R. 88 W. The independent closure of this structure is probably less than 350 feet, although the closure of the larger uplift upon which it is located may be as much as 2,000 feet. The area within the closure at Mahoney is estimated at 1,200 acres. The Carlile shale is the oldest Upper Cretaceous member exposed.

GAS FIELDS DISCOVERED OR EXTENDED DURING 1938

MONTANA

Cut Bank gas area.—Four miles northeast of the Cut Bank gas area, and midway between this field and the Border field in Toole County, A. B. Cobb deepened and completed his State No. 1, in the center of NE. ¼, NE. ¼ of Sec. 30, T. 37 N., R. 4 W., between the depths of 2,570 and 2,605 feet. This well flowed 40 million cubic feet of gas daily from a sand zone above the Cut Bank sand. Initial production tests on the upper part of this sand zone were carried on during December, 1937. Although no direct correlation of this sand has been made as yet, its depth and stratigraphic position suggest that it may be the equivalent of the Moulton sand in the main Cut Bank gas field and in the newly discovered North Cut Bank oil-producing area, located in Sec. 23, T. 37 N., R. 5 W.

The local structure in the vicinity of this discovery well and the probable extent of the gas area are unknown at this time. Regionally, the area falls on the west flank of the broad Sweetgrass arch; and, in the absence of definite information regarding local folded structure,

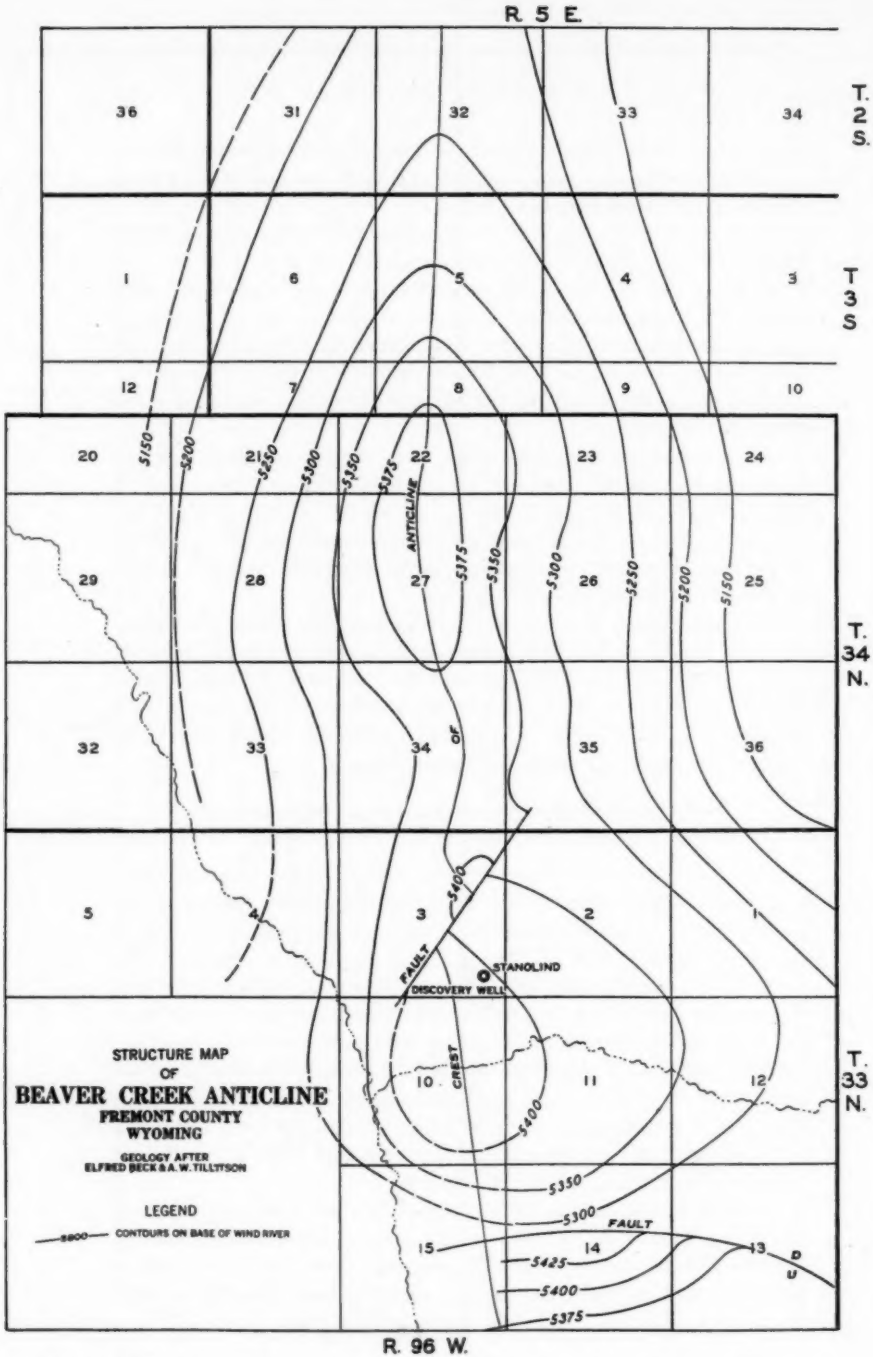

FIG. 5.—Surface structural contour map of Beaver Creek anticline, Fremont County, Wyoming.

it is assumed that the gas accumulation has resulted from lenticularity of sands in the Moulton sand zone.

UTAH

Clay Basin.—The Mountain Fuel Supply Company's Murphy No. 3-B, located in the NW. ¼, NW. ¼, SW. ¼ of Sec. 23, T. 3 N., R. 23 E., Daggett County, Utah, extended the gas-producing area of the Clay Basin field one mile east when it was completed producing at the rate of 14½ million cubic feet of gas per day from the Dakota sandstone at 5,925 feet, plugged depth. The hole was originally bottomed at 6,035 feet, 55 feet in the Morrison formation.

At the present stage of development, the Clay Basin field has five Dakota sand gas producers, and a single producer from a sand in the Frontier formation. As yet, the limits of neither zone have been established, but the proved Dakota sand area is in excess of 1,500 acres.

WYOMING

Beaver Creek.—The discovery well on the Beaver Creek dome, Fremont County, Wyoming—the Stanolind Oil and Gas Company's Government No. 1, center of SE. ¼, SE. ¼ of Sec. 3, T. 33 N., R. 96 W.—began drilling in 1937, and was completed on June 3, 1938, producing 9 million cubic feet of gas in a sand of the Morrison formation at 8,244–8,288 feet. The well was plugged back from a total depth of 8,920 feet, where it had tested water in the basal Sundance sand (Nugget). Other formational markers reported in this well are as follows.

	Depth in Feet
Base of Wasatch	1,400
Base of Lewis shale	1,700
Base of Mesaverde	2,760
Top of Frontier	6,760
Top of Mowry	7,301
Top of Muddy	7,939
Top of Dakota group	8,130
Top of Morrison	8,164
Top of Sundance formation	8,490
Top of Nugget	8,809

In the absence of a ready market for the gas from the Beaver Creek dome, no further development of the structure has occurred. The extent of the gas reserves in this structure can not be estimated, at this time.

The Beaver Creek anticline is a fairly well developed anticlinal fold, roughly paralleling the Big Sand Draw line of folding. It is traceable on the surface in beds of Wind River age, from the vicinity of Sec. 14, T. 33 N., R. 96 W., 6th P. M., into the southwestern part of T. 2 S., R. 5 W., W. R. B. & M. Two surface closures are noted on

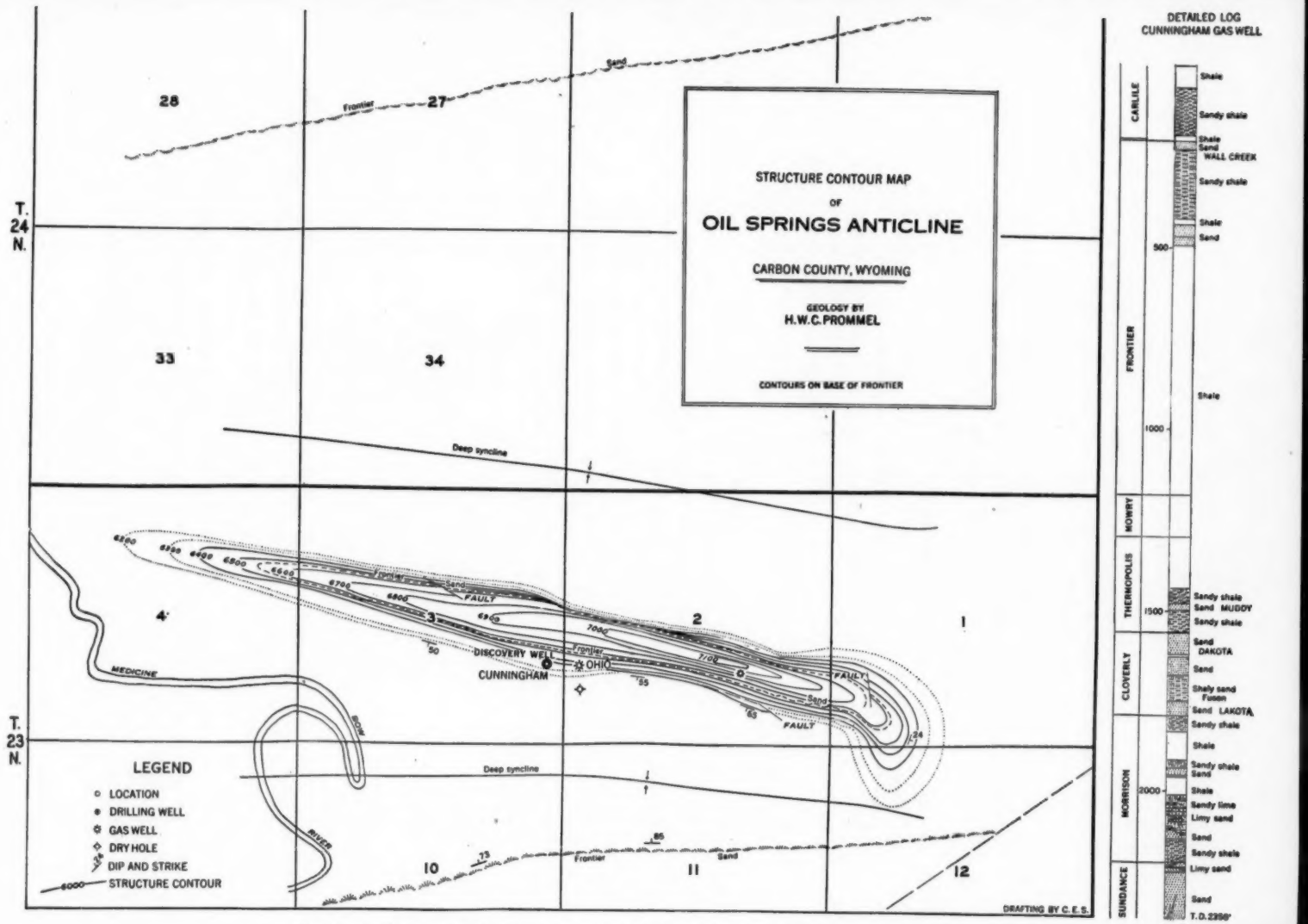

FIG. 6.—Surface structural contour map of Oil Springs anticline, Carbon County, Wyoming.

the Beaver Creek axis, the Beaver Creek dome itself centering near the location of the discovery well, in the SE. ¼ of Sec. 3, T. 33 N., R. 96 W., the Riverton dome centering in the N. ½ of Sec. 27, T. 34 N., R. 96 W. The location of the discovery well was made after a reflection-seismograph survey.

Muskrat.—The gas-producing area of the Muskrat field, Fremont County, Wyoming, was given a substantial extension in June, 1938, by the completion of the Sinclair-Wyoming Oil Company's Muskrat No. 2-B, NW. ¼, NW. ¼, NE. ¼ of Sec. 4, T. 33 N., R. 92 W. An initial production of 40 million cubic feet of gas is recorded from the Lakota sand at 5,306–5,321 feet, total depth.

The discovery well, which was located after reflection-seismograph surveys carried on during 1936, is probably on a separate closure closely related to, although some distance west of, the Muskrat line of folding.

The extent of reserves proved by this well can not be stated at this time, inasmuch as no further development of the new area has taken place.

Oil Springs.—The Oil Springs structure is a small, tightly folded anticline, on the north flank of the Flat Top uplift, in Secs. 1, 2, 3, and 4, T. 23 N., R. 79 W., Carbon County, Wyoming.

The discovery well, the Cunningham Oil Company's U. P.-Cronberg No. 1, located in the NE. ¼, SE. ¼, NE. ¼ of Sec. 3, T. 23 N., R. 79 W., was completed on June 2, 1938, producing 55 million cubic feet of gas from the Sundance sand at 2,231–2,350 feet, total depth.

The second gas well on the Oil Springs structure, the Ohio Oil Company's Baker No. 3, SW. ¼, NW. ¼, SW. ¼ of Sec. 2, T. 23 N., R. 79 W., was completed in the Lakota sand in December, 1938, producing an estimated 20 million cubic feet of gas. No production was expected from this zone, because of the results obtained in the discovery well. While drilling a short distance below the top of the Lakota formation, the well blew out of control, and is estimated to have flowed as much as 120 million cubic feet of gas, with water, before being brought under control.

At this time, no estimate can be made of the area likely to be productive of gas in commercial quantities from the two known gas-bearing formations, but the small size of the structure indicates that it will be considerably less than 1,000 acres.

FIG. 6.—Surface structural contour map of Oil Springs anticline, Carbon County, Wyoming.

AREA OF PRINCIPAL DEVELOPMENT IN 1938

MONTANA

The decline in activity in Montana as a whole, which was noted in 1937, continued into 1938. Total operations of all descriptions recorded

for 1938 are placed at 167, of which 71 were oil wells, 9 were gas wells, 8 were wildcat failures, 23 were field-well failures, 14 were wildcat wells suspended during the year, 10 were field wells suspended during the year, 9 were wildcat wells still incomplete on January 1, 1939, and 21 were field wells still incomplete on January 1, 1939. The loss of Canadian markets, resulting from the development of the Turner Valley field in Alberta, is still being keenly felt in the Montana oil industry.

Cut Bank.—In the Cut Bank field, Glacier County, Montana, only 40 completions were recorded during 1938, as against 71 for 1937 and 122 for 1936. Of these, 31 were oil wells, 5 were gas wells, and 4 were wells abandoned without production. Production of oil for the field in 1938 is placed at 2,801,000 barrels, a loss of 532,000 as compared with 1937. As of January 1, 1939, the field contains 412 oil wells and 69 gas wells.[6]

Kevin-Sunburst.—As in the past, the Kevin-Sunburst field, Toole County, Montana, furnished the greatest number of operations and completions of all the fields in the Rocky Mountain region. Despite this fact, the decline in completions is approximately 50 per cent, as compared with 1937.

A total of 74 operations of all descriptions for the field was recorded during 1938. Of these, 36 were oil wells, 2 were gas wells, and 15 were abandoned dry holes. Eight wells were suspended for various reasons during the year, and 13 were still drilling and incomplete on January 1, 1939. Total completions for the year were 53, as against 107 for 1937 and 73 for 1936.

New initial oil production from the 1938 completions amounted to approximately 1,600 barrels per day, and gas production approximately 4 million cubic feet. As of January 1, 1939, the combined Kevin-Sunburst field contained 1,162 oil wells and 176 gas wells.[6] Oil production for the year amounted to approximately 1,263,557 barrels, a loss of 369,500 barrels as compared with 1937.

NEW MEXICO

Rattlesnake.—The Rattlesnake field, San Juan County, New Mexico, reported 18 operations during 1938, of which 13 were oil wells and 5 were abandoned as non-productive. An estimate of new potential production resulting from completions in this field is placed at 735 barrels per day.

[6] These figures do not take account of routine abandonment of old oil and gas wells in the field during 1938.

WYOMING

Operations in Wyoming during 1938 totaled 184, of which 64 were oil wells, 20 were gas wells, 32 were abandoned without production, 38 were incomplete and suspended during the year for various reasons, and 30 were active and incomplete as of January 1, 1939. Completions for the year number 116, as against 117 for 1937.

Lance Creek.—The Lance Creek field, Niobrara County, Wyoming, continued to be the most active field in Wyoming during 1938. The impetus to drilling and development at Lance Creek, provided by the discovery of prolific production in the Leo sand of the Minnelusa formation (Pennsylvanian), carried over into 1938. The field recorded a total of 25 completions during the year, of which 18 were Leo sand oil wells, 1 was a Leo sand gas well, 1 was a Leo sand dry hole, 4 were Sundance sand oil wells, and 1 was a Dakota sand dry hole.

The average daily initial production of the 1938 Leo sand wells was 1,450 barrels, and of the Sundance sand wells 820 barrels. In 1937, total completions numbered 23, of which 10 were Leo sand oil wells, 12 were Sundance sand oil wells, and 1 an abandoned dry hole.

On January 1, 1939, Sundance sand oil wells numbered 54, Leo sand oil wells numbered 27, Leo sand gas wells numbered 1, and Converse sand (upper Minnelusa) oil wells numbered 1.

Lost Soldier.—The Lost Soldier field, Sweetwater County, Wyoming, completed a total of five oil wells during 1938, two of which were Tensleep sand wells, and the remaining three, Sundance sand wells. Combined daily initial production from the new completions totaled approximately 1,360 barrels.

Medicine Bow.—The Medicine Bow field, Carbon County, Wyoming, completed three Sundance sand oil wells and one Sundance sand gas well during 1938, and recorded one failure during the same period. The failure, The Ohio Oil Company-The California Company's State No. 3, center of SW. ¼, NW. ¼ of Sec. 36, T. 21 N., R. 79 W., defined the southern limit of First Sundance sand production when it found water in the sand, and was abandoned at 5,711 feet, total depth.

Combined initial production from the oil wells amounted to approximately 1,800 barrels, and from the gas well 10,900,000 cubic feet daily.

Osage.—The old Osage field of Weston County, Wyoming, showed a large amount of activity and many completions, although the combined initial production of the new completions is not large. A total of

35 completions occurred in this field during 1938, of which 9 were dry holes and 26 were oil wells, with a combined initial production of approximately 735 barrels per day.

Salt Creek. The year 1938 witnessed the completion of seven Tensleep sand (Pennsylvanian) oil wells at Salt Creek, Natrona County, Wyoming, by the Stanolind Oil and Gas Company. The average depth of these wells is approximately, 4,000 feet, and the combined initial oil production of the seven completions is estimated at 1,100 barrels per day.

IMPORTANT DRY HOLES

COLORADO

Kit Carson.—A deep test of considerable importance and bearing on the oil possibilities of eastern Colorado was abandoned during 1938. The Gulf Oil Corporation's U. P.-Larsen No. 1, located 8 miles north of the town of Kit Carson, in Sec. 13, T. 13 S., R. 49 W., Cheyenne County, Colorado, was abandoned in pre-Cambrian rocks in June, 1938, at a total depth of 6,360 feet. This well, which was located after a seismic survey, found encouraging showings of oil in a porous limestone at 4,808–4,813 feet, which is tentatively correlated with a part of the Kansas City limestone of Pennsylvanian age. Exhaustive tests of these "showings" failed to yield production, however.

The section penetrated below the Kansas City limestone equivalent is apparently normal for this district, and includes Marmaton and Cherokee beds of Pennsylvanian age, Chester (?) and Madison beds of Mississippian age, Ordovician rocks equivalent to at least the Simpson (Harding) and Arbuckle (Manitou) formations, and the Sawatch formation of Cambrian age. The top of the Arbuckle (Manitou) was logged at 5,941 feet, and the top of the Sawatch at 6,296 feet.

Ramah.—After a seismic survey, the Plymouth Oil Company drilled and abandoned its U. P.-Brosky No. 1 in the center of SW. ¼, SW. ¼ of Sec. 19, T. 10 S., R. 60 W., Elbert County, Colorado, at a total depth of 7,578 feet. Surface beds in this area belong to the Denver-Arapahoe group of Eocene age. Although few details of drilling have been released, this well is reported to have found water in the Dakota at a depth of approximately 6,770 feet, and to be in the Fountain formation of Pennsylvanian age at its total depth.

MONTANA

Big Lake.—The Big Lake structure in Stillwater County, Montana, has been a producer of gas and oil in minor amounts from Cretaceous sands (Lower Cretaceous) at relatively shallow depths for many years. Oil occurs in a sand of the Kootenai formation (Lower

Cretaceous), and gas is produced from the Eagle sand and sands in the Frontier formation—both gas zones being of Upper Cretaceous age.

In May, 1938, the Indian Territory Illuminating Oil Company began the deepening of the old Delmar Oil Company's Hepp No. 2, located in the northwest corner of Sec. 25, T. 1 N., R. 21 E., with a test of the Madison limestone as its objective. This well was abandoned without favorable showings at a total depth of 6,002 feet. The top of the Madison limestone is tentatively placed at 5,150 feet, at which point it unconformably underlies the Amsden formation. The deep section drilled in this well corresponds, therefore, with the surface section observed in the north end of the Pryor Mountains.

Broadview dome.—The Broadview dome, located in Yellowstone County, Montana, has been the scene of numerous shallow tests over a period of years. However, no production of consequence from the shallow Cretaceous members was developed. During 1938, the Signal Oil and Gas Company's Stoltenberger No. 1, SE. ¼, SE. ¼, NW. ¼ of Sec. 18, T. 3 N., R. 23 W., was drilled to a total depth of 5,129 feet, and abandoned without favorable showings. The top of the Madison limestone is placed tentatively at 4,282 feet. The log of this well is interesting, in that it shows a thickness of 820 feet of beds above the Madison limestone, which are correlated with the Big Snowy group of upper Mississippian age.

Dupuyer.—The Dupuyer anticline is a sharp fold, lying in the disturbed belt of Teton County, immediately east of the bold mountain front formed by the Lewis thrust fault. A closure of several hundred feet is expressed in the beds of Kootenai age, as shown at the surface.

In August, 1938, The California Company began drilling its Dupuyer Unit No. 1, located in the NE. ¼, SE. ¼, SW. ¼ of Sec. 26, T. 27 N., R. 9 W. This well was drilled to a total depth of 2,814 feet, at which point it was abandoned in Colorado shale, after drilling through a fault at a depth of approximately 2,560 feet. A normal section (including the Ellis, Madison, Three Forks, and Jefferson formations) was drilled to 2,560 feet, at which point the Jefferson was found in fault contact with Colorado shale. No showings were encountered in drilling, and the well was abandoned without production on October 31, 1938.

NEBRASKA

Agate.—The Agate structure is an elongate east-west trending anticline, expressed in beds of the Harrison formation of Tertiary age, lying in the central part of T. 28 N., R. 55 W., Sioux County,

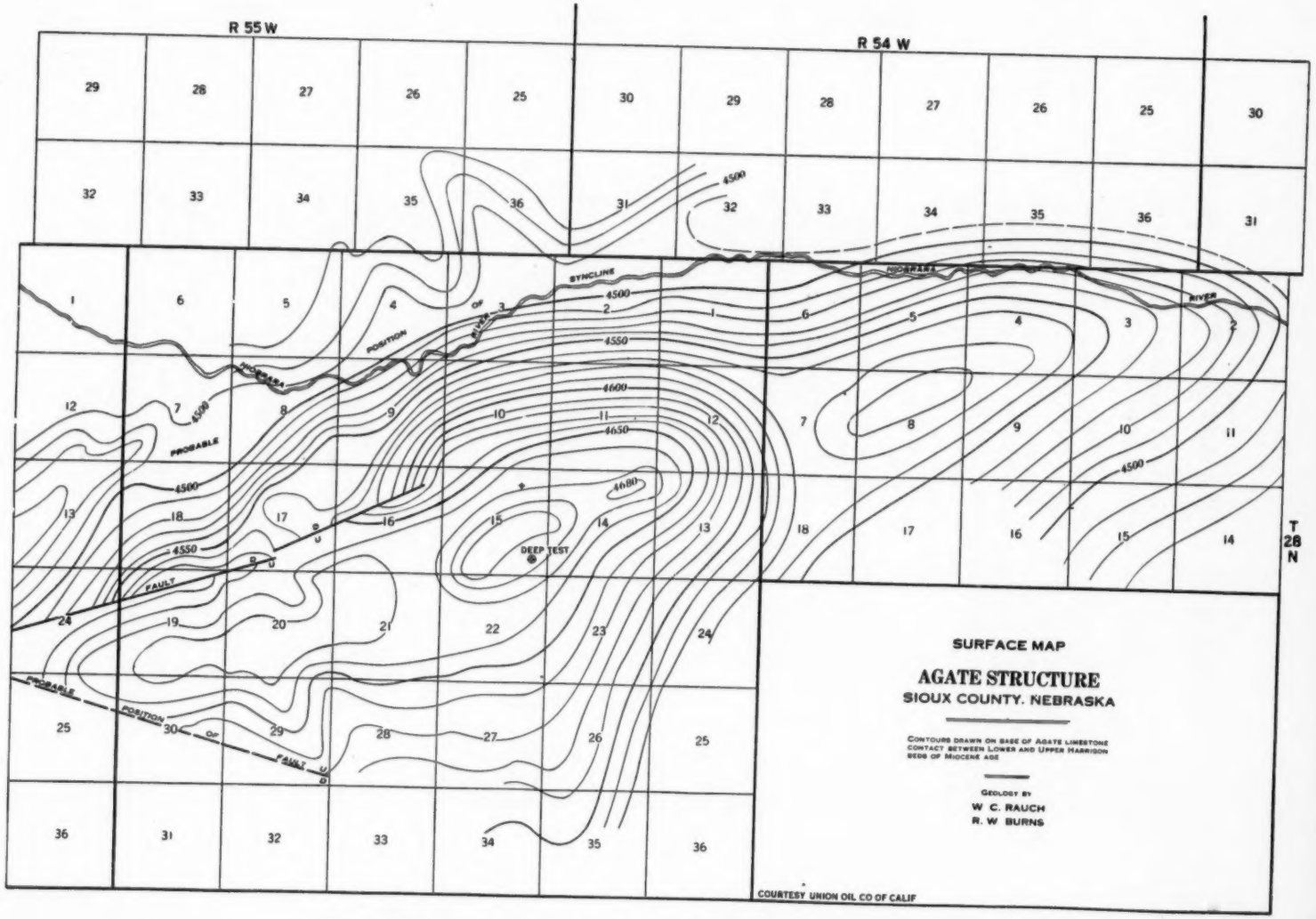

FIG. 7.—Surface structural contour map of Agate structure, Sioux County, Nebraska.

Nebraska. In 1920–1921, the Associated Oil Company of Wyoming drilled and abandoned Cook No. 1, NE. ¼, Sec. 15, T. 28 N., R. 55 W., at a total depth of 4,567 feet. At this depth, the well was apparently in the Graneros formation (Upper Cretaceous), just above the Newcastle (Muddy) sand.

In April, 1938, the Union Oil Company of California began drilling its Agate No. 15-1, located in the NW. ¼, SE. ¼, SE. ¼ of Sec. 15, T. 28 N., R. 55 W. This well was drilled to a total depth of 6,846 feet, at which point it was abandoned because of unsurmountable mechanical difficulties. At its total depth, this well was presumably still in Pennsylvanian beds, equivalent to a part of the Minnelusa formation of the Black Hills Region.

The log of this well has been discussed in a geological note, published in the *Bulletin* of the American Association of Petroleum Geologists, Vol. 23, No. 1 (January, 1939), page 101. A few slight oil cuts were obtained from dense dolomitic limestone below 6,363 feet. In view of the presence of a prominent surface structure, and of the fact that the lower beds of the Paleozoic section were not reached, the test can not be construed as entirely conclusive. A second test of this structure may be drilled during 1939.

Sandford (Whistle Creek).—South of the Agate structure, in T. 27 N., R. 55 W., the Felmont Corporation mapped a surface structure in the Harrison beds of Tertiary age, and subsequently located its Kinion No. 1 in the SW. ¼, NE. ¼ of Sec. 21, T. 27 N., R. 55 W., after a seismic check of the area.

This well was drilled to its contract depth of 6,506 feet, and abandoned at this point without favorable showings or production. The Kinion well was bottomed in Pennsylvanian beds, equivalent to some part of the Minnelusa formation of the Black Hills, but lacked several hundred feet of obtaining the stratigraphic penetration of the Agate test, in Sec. 15, T. 28 N., R. 55 W. A correlation of the two wells indicates that the Kinion well is approximately 140 feet lower structurally than the test at Agate.

FIG. 7.—Surface structural contour map of Agate structure, Sioux County, Nebraska.

NORTH DAKOTA

Nesson.—During 1938, The California Company achieved a record for deep drilling in the Rocky Mountains and High Plains regions in the drilling of its test of the Nesson anticline, Williams County, North Dakota. This well was begun in September, 1937, and was abandoned in August, 1938, at a total depth of 10,281 feet, because of mechanical difficulties.

The Nesson anticline was the scene of a previous test, when the Big Viking Oil Company drilled and abandoned a well in the SE. ¼,

NW. ¼ of Sec. 3, T. 154 N., R. 96 W., at a depth of 4,642 feet. The well at this depth was apparently in the upper part of the Morrison formation (Jurassic?).

The California Company's Nels Kamp No. 1, center of NW. ¼, NE. ¼ of Sec. 3, T. 154 N., R. 96 W. (rotary-table elevation, 1,927 feet) began drilling in the Fort Union formation of Eocene age. The top of the Pierre formation (Upper Cretaceous) was logged at 1,030 feet, and the formations encountered from this depth to 6,485 feet (top of the Minnekahta (?) dolomite) conform to a normal Black Hills section. Below 6,485 feet, however, attempts to correlate definitely with known formations in the Rocky Mountains and this part of the Plains region met with only moderate success.

The section from 6,561 to 7,710 feet is predominantly vari-colored shales and sandy shales, with minor amounts of red and purplish sand and limestone in thin beds. Red coloration is prominent below 7,200 feet, and the interval from this point to 7,710 feet is characterized by clear crystalline salt as cavity fillings in the red sandy shales, or as distinct salt layers several feet thick. Some anhydrite is also present in varying quantity throughout this zone. Below, 7,710 feet, anhydrite and salty dolomite become increasingly dominant. Salt is noted in the dolomite at least to 7,900 feet. Below this point, limestones predominate and continue, with little interruption, to bottom, 10,281 feet.

In all probability, the equivalent of the Minnelusa formation (Pennsylvanian) of the Black Hills is represented in the well section somewhere in the terrigenous member below 6,561 feet. Fossil evidence of beds of Pennsylvanian age is entirely lacking, however. There is reason to believe, on the basis of fossil determinations, that Mississippian beds of both pre- and post-Madison (lower Osage) age were drilled, but it has been impossible to place, with certainty, either the upper or lower limits (if reached) of beds belonging to this period.

The broad arch of the Nesson anticline is well exposed in the Fort Union beds along the Missouri River and its tributaries near the Kamp well No. 1. The structure was mapped at the surface during the summer of 1936, and extensively surveyed by seismic methods during the spring and summer of 1938. The structure as mapped is the most prominent in the Plains region, and, while a single deep test can not be construed as condemning the entire region, its negative results will no doubt serve to place a damper on further exploration.

WYOMING

Hat Creek.—The Hat Creek anticline lies in the northwestern part of T. 34 N., R. 62 W., Niobrara County, Wyoming. It is on the same

trend as the Old Woman anticline, and about 12 miles south of the "high" of the latter structure. Faulting is prominent along the axial part of the Hat Creek structure, and beds of the Morrison formation (Jurassic?) are exposed.

In October, 1938, The Ohio Oil Company began drilling its Hat Creek test well, Jones Permit No. 1, SW. ¼, NE. ¼, SE. ¼ of Sec. 30, T. 35 N., R. 62 W. This well was carried to a depth of 2,934 feet in December, 1938, where it was abandoned without production, presumably in pre-Cambrian rocks. A normal Lance Creek section of the Minnelusa (Hartville) formation is present in the well section. The top of the Converse sand is placed at 1,266 feet, the top of the Leo sand zone at 1,867 feet, and the top of the Bell sand zone at 2,439 feet. The top of the Madison limestone is tentatively placed at 2,525 feet. A definite correlation of the generally calcareous section between this point and the bottom of the hole is still a matter of some difference of opinion. A green shale zone about 10 feet thick is logged at 2,708–2,718 feet, and this lithologic break is construed by some as indicating the base of the Madison limestone. The limestone below may, therefore, belong to the Englewood formation (Mississippian), to the Whitewood formation (Ordovician), or to the Deadwood formation (Cambrian). Its lithologic character does not suggest the Deadwood formation, and the presence of the Whitewood so far south has not hertofore been recognized.

Medicine Bow.—The Medicine Bow structure, T. 21 N., R. 79 W., has produced oil and gas prolifically for several years, from sands of the Sundance formation. No test of deeper horizons was attempted, however, until 1938, when The Ohio Oil Company-The California Company's Kyle No. 3, center of SW. ¼, NE. ¼ of Sec. 26, T. 21 N., R. 79 W., was deepened from an old total depth of 5,765 feet to a depth of 7,854 feet, without favorable results. This well was subsequently plugged back to 5,661 feet, and recompleted as a small First Sundance sand oil well.

At its total depth, the Kyle well No. 3 was 24 feet in pre-Cambrian granite. During deepening, the Jelm sand was logged at 6,020–6,060 feet, the top of the Permo-Triassic anhydrite section at 6,669 feet, Embar limestone at 6,790–6,820 feet, top of the Tensleep sand (Casper formation) at 7,008 feet, and top of the pre-Cambrian granite at 7,830 feet. The Casper formation in this part of the Laramie basin is roughly equivalent to the Minnelusa and Hartville formations of the Black Hills and Hartville uplifts, respectively. In all probability, no Madison limestone is present in this test, and the Casper formation rests directly on granite.

The failure of the Kyle well No. 3 to develop Tensleep production

adds another well to a long list of Tensleep failures drilled in Laramie basin. The Medicine Bow structure is by far the most prominent of Laramie basin folds, and the failure of this test to develop Tensleep sand production may be interpreted as definitely lessening the chances for Tensleep production from other untested structures in Laramie basin.

INTERESTING WELLS DRILLING OR INCOMPLETE ON JANUARY 1, 1939

COLORADO

Eastern Colorado.—January 1, 1939, found the Continental Oil Company drilling its Rosabell Ruby No. 1, center of NE. ¼, NW. ¼ of Sec. 31, T. 21 S., R. 44 W., Prowers County, Colorado, at a depth of 5,434 feet. This well is located on the Cottonwood structure, a well defined surface dome in Upper Cretaceous rocks.

At the time of this writing (March 18, 1939), Ruby No. 1 has been abandoned without production or favorable showings of oil or gas at a total depth of 5,680 feet, 116 feet into the Arbuckle (Manitou) limestone of Ordovician age. The section penetrated in Ruby No. 1 is essentially similar (except for some variation in thickness of individual members) to other deep wells drilled in this part of eastern Colorado. The sea-level position of all the lower stratigraphic markers indicates that the location is low on the eastern flank of the northern extension of the Las Animas or Sierra Grande uplift.

The abandonment of this test marks another somewhat discouraging episode in the short but intensive search for oil in Paleozoic rocks of eastern Colorado. Although ten deep, dry holes can not be construed as definitely condemning an area of the dimensions of eastern Colorado, it is generally believed that the area embraced by these deep tests is the most favorable, generally speaking, of the Plains area of eastern Colorado, and that the recording of two failures during 1938 and early 1939 will tend to retard further development.

Divide Creek.—The Divide Creek anticline, located in Ts. 7, 8, and 9 S., R. 91 W., Garfield and Mesa counties, Colorado, was the scene, during 1938, of continued drilling by the Continental Oil Company, The California Company, and the Amerada Petroleum Corporation on their joint test of the structure, D. B. Miller No. 1, SW. ¼, SW. ¼, NW. ¼ of Sec. 36, T. 8 S., R. 91 W., Mesa County.

Miller No. 1 was shut down for the winter of 1938–1939 at a depth of 9,410 feet, still above the Dakota sand. At the date of this writing (March 18, 1939), winter has not yet broken, and operations for 1939 have not yet begun.

The Divide Creek anticline is one of the largest in the region,

having a length of approximately 18 miles, and a closure estimated at 2,000 feet, involving approximately 15,000 acres within the lowest closing contour.

WYOMING

Big Piney.—An interesting development in the Big Piney area occurred late in 1938, when the Wyoming Petroleum Corporation's Chas. Budd No. 1, located in the center of the NE. ¼, NE. ¼ of Sec. 10, T. 29 N., R. 113 W., Sublette County, Wyoming, blew out of control while shut down for the winter at a depth of 1,765 feet. The well is estimated to have flowed from 10 to 25 million cubic feet of gas together with an unknown quantity of water. Out of control for several weeks, the well was finally killed and shut in for the winter. Sub-zero weather in Wyoming during this period hindered progress of remedial work around the ice-encrusted location.

There is no evidence available at this time indicating the presence of any favorable structure at this location. The surface beds belong to the Wasatch formation of Eocene age, which, in this part of the Green River Basin, discloses a low regional dip toward the east off the Wyoming Range. Some gas was noted in drilling at several places between 800 feet and bottom, but it can not be stated with assurance which zone contributed the gas which blew out of control. It seems fairly certain that the well, at its present total depth, is still in the Wasatch formation. Furthermore, the apparent absence of any important foldings suggests that the gas accumulation is the result of lenticularity of sand beds within the Wasatch.

Dry Piney.—The Dry Piney structure, located in the northeast corner of T. 28 N., R. 114 W., Sublette County, Wyoming, has produced negligible amounts of light oil in the past, from shallow sand lenses in the Hilliard formation (Upper Cretaceous). The structure is fairly well exposed in the basal Wasatch beds except on the southwest side, where the Darby thrust fault over-rides the Dry Piney fold and a mantle of talus obscures the exposures of the Wasatch formation. Adaville beds (Mesaverde) are exposed on the crest of the fold, and the top of the Hilliard shale is reported to lie at 100 feet depth.

A proposed Frontier test of this structure was begun in August, 1938, when the Frontier Petroleum Company of Los Angeles spudded its Government No. 1, SE. ¼, SE. ¼, SW. ¼ of Sec. 1, T. 28 N., R. 113 W. The hole was drilled to approximately 5,950 feet, at which depth the well blew out from an unknown depth and flowed gas at an estimated rate of 25 million cubic feet for several days before it was brought under control. At this point in the progress of the well, The Texas Company took over operations, installed heavy rotary equip-

ment, and set 5,607 feet of 7-inch casing. A large part of the period since December, 1938, has been spent in conditioning the hole and cementing off shallow gas which is escaping from craters around the rig. At the present time (April 15, 1939), the well has reached a depth of 6,892 feet. The top of the Frontier sandy zone is placed at 5,700 feet, more or less.

PIPE-LINE CONSTRUCTION DURING 1938

The major pipe-line project of the Rocky Mountain region for 1938 was the construction of a 232-mile trunk oil line from the Lance Creek field, Niobrara County, Wyoming, to Denver, Colorado. This line was built by the Rocky Mountain Pipe Line Company, and will supply Lance Creek crude to several refineries between Cheyenne, Wyoming, and Denver, Colorado.

Construction of the line was begun in August, 1938, and it was placed in operation on November 1, 1938. It consists of 136 miles of 8-inch pipe from Lance Creek to Cheyenne, and 96 miles of 6-inch pipe from Cheyenne to Denver. Its capacity is rated at 10,000 barrels per day.

Late in 1938, the Continental Oil Company completed a 66-mile oil line from the Lance Creek field, Wyoming, to its refinery at Glenrock, Wyoming. The line consists of 14.9 miles of 6-inch and 51.5 miles of 4-inch pipe.

During 1938, the Mountain Fuel Supply Company completed an 18-inch loop system to its main gas line between Bigelow Hills, east of Evanston, Wyoming, and Coalville, Utah, a distance of 53 miles. This pipe-line system is the outlet for gas from gas fields in southern Wyoming, northwestern Colorado, and northeastern Utah.

The Northern Utilities Company completed the looping of its Muskrat-Casper gas line during 1938.

PRODUCTION

Table I contains production figures for the Rocky Mountain region, by states, for the years 1936, 1937, and 1938. A comparison of

TABLE I*

State	*1936*	*1937*	*1938*
Colorado	1,612,760	1,578,391	1,324,374
Montana	5,798,661	5,799,364	4,824,917
New Mexico	378,926	382,687	344,637
Wyoming	14,268,839	19,637,218	18,956,277
Totals	22,059,186	27,397,660	25,450,205

* Production figures from *The Oil and Gas Journal* (January 26, 1939). Figures on New Mexico include only production from the San Juan Basin fields.

these figures shows a decline in production of 1,847,455 barrels in 1938.

SUMMARY OF OPERATIONS IN ROCKY MOUNTAIN REGION, 1938

Table II summarizes operations of all descriptions in the Rocky Mountain region during the year 1938.

TABLE II

State	*Wildcat Wells*					*Field Wells*					*Total*
	Completions				*Drlg.*	*Completions*				*Drlg.*	
	Oil	*Gas*	*Ab'd.*	*Susp.*	*1-1-39*	*Oil*	*Gas*	*Ab'd.*	*Susp.*	*1-1-39*	
Colo.	1	0	8	15	14	6	0	0	1	0	45
Mont.	1	1	8	14	9	71	9	23	10	21	167
Nebr.	0	0	4	2	1	0	0	0	0	0	7
N. Mex.*	0	0	8	9	11	20	4	9	4	9	74
N. Dak.	0	0	1	0	0	0	0	0	0	0	1
Utah	0	0	2	1	1	0	1	0	0	0	5
Wyo.	3	2	12	20	12	61	18	20	18	18	184
Totals	5	3	43	61	48	158	32	52	33	48	483

* Includes only operations in San Juan basin of northwestern New Mexico.

It will be noted that the total number of well completions decreased from 375 in 1937 to 293 in 1938. During the same period, the number of oil-well completions totaled 163, as compared with 220 in 1937; gas well completions totaled 35, as compared with 39 in 1937. The downward trend in operations noted in 1937 carried over into 1938, and is reflected in the summary figures of Table II. Wildcat activity, on the other hand, was on a par with 1937, and it may be significant that January 1, 1939, saw 48 wildcat operations of all descriptions in various stages of progress.

CONCLUSIONS

The year 1938 was marked by routine development and expansion of known producing fields. In addition, the active wildcat exploration rate maintained during the year resulted in the discovery of several new oil- and gas-producing areas which should ultimately be instrumental in adding materially to the known oil and gas reserves of the Rocky Mountain region. Whether the new discoveries for the year will balance the withdrawals is still a matter of some doubt.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE, 1939), PP. 932-948, 8 FIGS.

ADDITIONS TO OIL RESERVES IN CALIFORNIA DURING 1938[1]

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ABSTRACT

Developments in California, including new discoveries and extensions of existing fields, added 253 million barrels of oil to the state's reserve, an amount which is slightly greater than consumption for this year. The success of exploration during the last 3 years has vastly improved over that for the preceding 4 years but only to the extent of discovering new oil at a rate comparable to the yearly demand.

GENERAL SUMMARY

Additions to known reserves.—Developments in California during 1938 added an estimated 253 million barrels to the state's known oil reserve, an amount which exceeds by 33 million barrels the year's demand for California crude. The net quantity of estimated reserves is, therefore, slightly higher than a year ago. Discovery of five new fields and new producing zones in four fields discovered in former years contributed an estimated 143 million barrels, while development of earlier discoveries, principally those of 1936 and 1937, accounted for the remaining 110 million barrels.

Present reserve supply and discovery rate.—Known oil reserves in California at the close of 1938 are estimated at 3,147 million barrels (Fig. 1). This quantity, although materially less than the 3,869 million barrels estimated for 1928, is 87 million barrels greater than the estimate for 1936.

Known reserves declined from 1928 to 1936 principally because exploration during the intervening 7 years was discouraged by the excessive flush production of Kettleman Hills, Elwood, and Santa Fe Springs, and, later, by more general adverse economic conditions. The return of more favorable conditions generally and within the industry, together with a realization that additional known reserves were needed, led to an increase in exploration and the distinct improvement in the discovery rate apparent for the last 3 years.

The present improved rate of discovery, although keeping pace with consumption, is not satisfactorily replenishing our decreased known reserve supply. Further improvement is desirable. The rate of discovery, however, appears to be directly related to the quantity of exploratory geology and drilling (Fig. 7, p. 946), and any increase in these activities, or continuation of their present rates, is now discouraged by the present excessive capacity to produce known reserves.

[1] Read before the Association at Oklahoma City, March 23, 1939.

[2] Chief geologist, Richfield Oil Corporation.

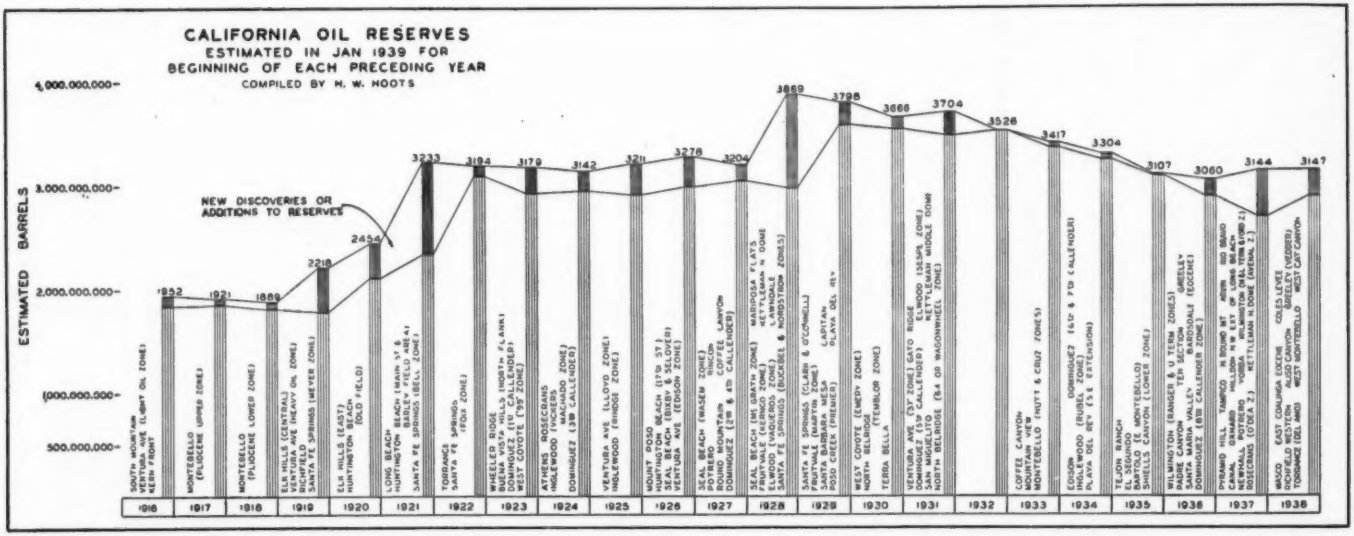

FIG. 1.—California oil reserves estimated for beginning of each year. Entire column indicates total estimated reserves. Upper part of columns prior to 1935 indicates present estimate of discoveries; upper part beginning with 1935 indicates new reserves added by reason of new discoveries and extensions of previously discovered fields.

Effect of excessive production on the discovery rate.—An excessive capacity to produce, or the actual production of excessive quantities of oil, does not necessarily result from the discovery of new fields but rather from the rapid drilling of too many wells in these new fields and the failure to adequately curtail their production. Production in excess of consumption naturally results in an excessive above-ground supply which threatens the price structure and creates general instability. Normal and necessary exploration for, and discovery of, additional reserves is discouraged. The common result is a progression of declining supply, threatened shortage, good prices, and renewed exploration followed by another period of excessive production.

Decrease of the production rate in conformity with the need for additional oil and with modern principles of maximum economic recovery is important from every viewpoint, particularly in times of ample supply. The present program of voluntary curtailment in California deserves more success. Progress has been made but complete and lasting success in bridling the enlarged capacity of the state to produce depends on the coöperation of every producer in following rules designed to be equally fair to all. The resulting stabilized conditions will insure maximum protection for our reserve supply of oil and will permit exploration for needed additional reserves to proceed with greater efficiency.

There are at present two distinct problems in California which should not be confused. One, the capacity to over-produce, requires that existing wells be equitably curtailed and that the rapidity of drilling additional wells in proved fields be reduced in conformity with the need for additional oil. The other, the increasing demand for oil and the relatively low position of our total known oil reserves, requires that every effort be expended to improve on the moderate success of the last 3 years and on the technique of finding oil. Wildcat drilling activity in California should not be allowed to decline.

Outlook for future discoveries.—The improved rate of oil discovery during the last 3 years and present information as to the geological possibilities of California strongly indicate that exploration, conducted in a consistent manner uninterrupted by periods of overproduction and instability, can provide an adequate supply of oil for many years.

Additions to Reserves During 1938

Additions to oil reserves are of two types: (1) geological discoveries of new fields and new zones, and (2) additions by reason of extension of area or the improvement of data provided by new wells in previously discovered fields.

NEW OIL FIELDS

Five new fields[3] were discovered in California during 1938. These additions to the state's oil reserve resulted from the individual and combined efforts of geologists and seismograph parties in mapping surface and subsurface geology. Two fields, one of them a stratigraphic trap and the most important discovery in two years, resulted from the efforts of geologists in mapping surface and subsurface structure and stratigraphy; the remaining three were found by use of the reflection seismograph.

WASCO FIELD

Location.—Four miles west of Wasco and 3 miles east of Lost Hills field in Sec. 8, T. 27 S., R. 24 E.

Discovery.—Made by the Continental Oil Company on completion of its K.C.L. No. A-2 in April, 1938. The well was completed flowing through the tubing with a daily initial production of 1,722 barrels of oil on a 12-hour gauge, 34.7° A.P.I. gravity, 7.2 per cent cut, $\frac{3}{8}''$ bean, 1,200–1,500 pounds tubing pressure, 50–200 pounds casing pressure, 164 M.c.f. of gas. The cut cleaned up to 0.1 per cent. Total depth is 15,004 feet, plugged to 13,998 feet. The producing sand, considered to be the Rio Bravo sand, lies between 13,100 and 13,175 feet. Before being completed this well, the deepest in the world, was drilled to 15,004 feet.

Development.—Two completions, two abandonments, and three locations.

Geology.—The structure is an anticlinal dome, apparently having comparatively small closure and areal extent.

Geologic method of discovery.—Reflection seismograph.

EAST COALINGA EOCENE FIELD

Location.—Five and one-half miles northeast of the town of Coalinga and 2 miles southeast of the old Coalinga field in Sec. 18, T. 20 S., R. 16 E.

Discovery.—Made jointly by the Petroleum Securities Company, Seaboard Oil Company, and Honolulu Oil Company on completion of their well No. 1–18F in July, 1938, with an initial daily production of 7,920 barrels of oil on a one-hour gauge, 32.1° A.P.I. gravity, 0.1 per cent cut, 38/64″ bean, 1,100 pounds tubing pressure, 1,375 pounds

[3] The Canfield Ranch area, discovered by the Standard Oil Company of California by completion of its K.C.L. No. 15–1 in January, 1938, is tentatively considered to be an eastern extension of the Ten Sections field. The initial daily production was 234 barrels of oil, flowing through a 16/64″ bean, 27.5° A.P.I. gravity. The average daily production for December, 1938, was 41 barrels.

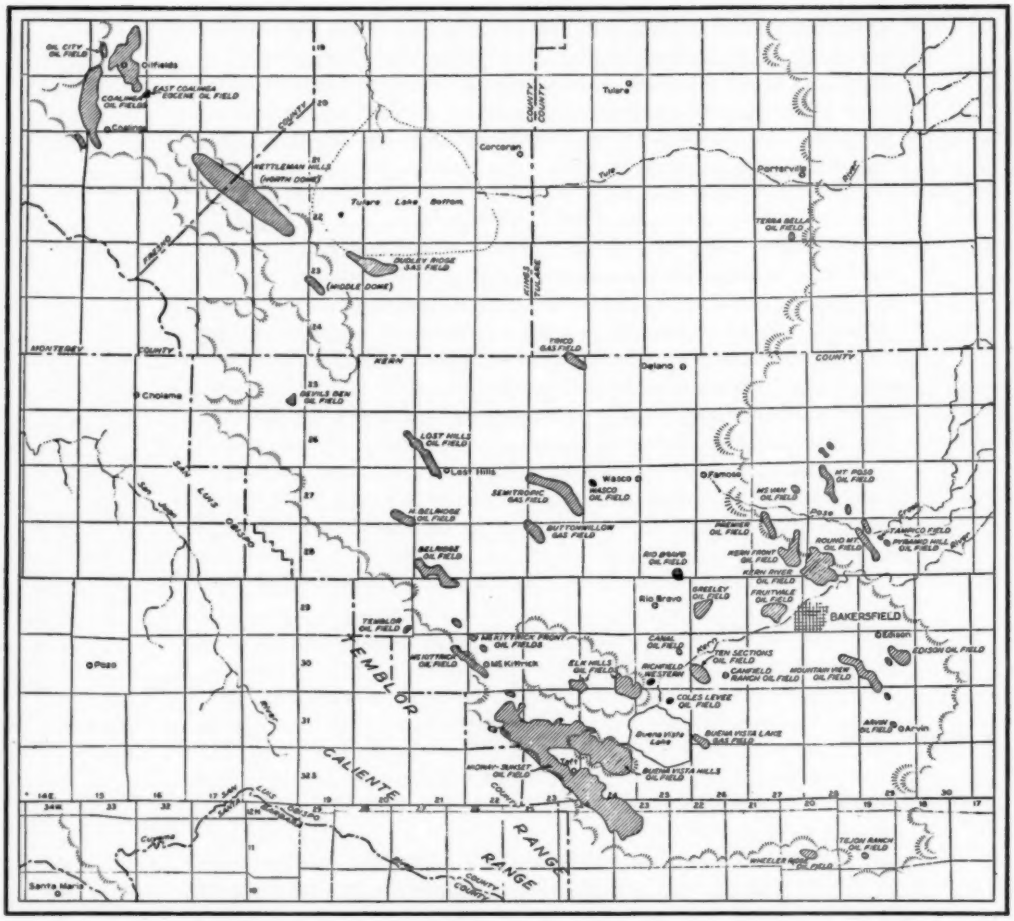

FIG. 2.—Southern San Joaquin Valley showing oil fields; new discoveries and extensions shown in solid black.

casing pressure, 7,000 M.c.f. of gas estimated. On the first 24-hour gauge the well flowed 753 barrels of oil, 33° A.P.I. gravity, 0.1 per cent cut, 12/64″ bean, 1,185 pounds tubing pressure, 1,575 pounds casing pressure, 365 M.c.f. of gas. Total depth is 6,908 feet. The producing zone is Avenal (or Gatchell) sand of Eocene age between 6,710 and 6,908 feet.

Development.—Nine completions, five drilling wells, two locations, and two abandonments. The discovery well stopped in oil sand. One of the later wells penetrated a 600-foot zone containing 587 feet of remarkably permeable medium coarse oil sand.

Geology.—Oil accumulation occurs in a 600-foot body of Eocene sand, the up-dip edge of which cuts northeastward across the prominent southeastward plunging Coalinga anticline and is overlapped by younger beds of silty shale.

Geologic method of discovery.—Field mapping and subsurface studies.

COLES LEVEE FIELD

Location.—Eighteen miles southwest of Bakersfield and 4½ miles southwest of Ten Sections oil field in Sec. 10, T. 31 S., R. 25 E.

Discovery.—Made by The Ohio Oil Company on completion of its well K.C.L. No. F-1 in November, 1938, with an initial daily production of 732 barrels of oil on a 16½-hour gauge, 44.5° A.P.I. gravity, 1.6 per cent cut, 48/64″ bean, 475 pounds tubing pressure, 900 pounds casing pressure, 3,900 M.c.f. of gas. Total depth is 9,365 feet. The producing zone is the Stevens sand between 9,220 feet and bottom.

Development.—There are two locations in the area.

Geology.—The structure is probably some sort of eastward plunging anticlinal nose, with westward closure dependent on the presence of either one or more faults or a stratigraphic trap or both.

Geologic method of discovery.—Reflection seismograph.

RICHFIELD-WESTERN FIELD

Location.—One mile east of Elk Hills field and 18 miles southwest of Bakersfield in Sec. 32, T. 30 S., R. 25 E.

Discovery.—Made by the Richfield Oil Corporation on completion of its Western No. A-32–32 well in November, 1938, with an initial daily production of 3,752 barrels of oil on a 4-hour gauge, 44.1° A.P.I. gravity, 4.8 per cent cut, 1½″ bean, 1,000 pounds tubing pressure, 1,000 pounds casing pressure, flowing. Total depth is 8,677 feet. Producing formation is the Stevens sand between 8,250 and 8,677 feet. Due to high gas-oil ratio the discovery well was recompleted January 4, 1939, producing from 128 feet of zone between 8,523 and 8,677 feet.

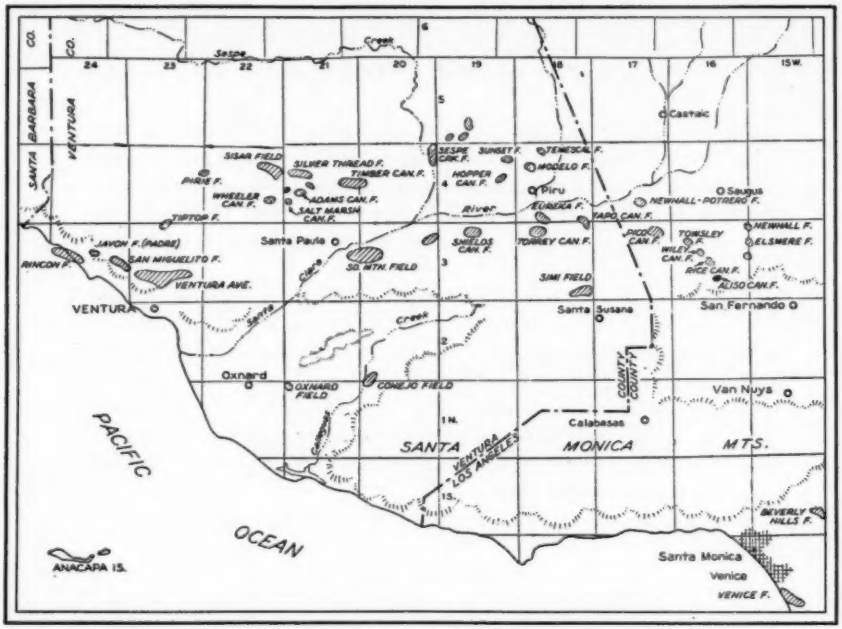

FIG. 3.—Ventura-Newhall district, showing new Aliso Canyon (solid black) near San Fernando.

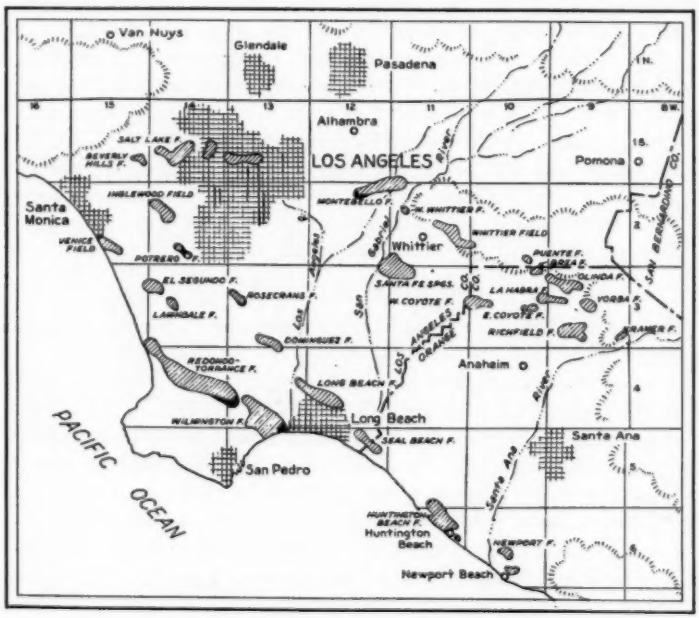

FIG. 4.—Los Angeles Basin fields with new discoveries and extensions shown in solid black.

On January 15, 1939, a potential of 2,112 barrels a day of 44° gravity oil was established. Gas production was reduced from 15,000 M.c.f. to 7,000 M.c.f. by this recompletion. Pressures at the present curtailed production rate are 2,950 pounds on the tubing and 2,550 pounds on the casing.

Geology.—Judging from available data, accumulation is due at least in part to the presence of a closed anticlinal structure developed on a prominent nose immediately east of the Elk Hills anticlinal uplift.

Geologic method of discovery.—Reflection seismograph.

ALISO CANYON FIELD

Location.—Four and one-half miles south of the town of Newhall and 6 miles northwest of San Fernando, Los Angeles County, in Sec. 27, T. 3 N., R. 16 W.

Discovery.—Made by the Tide Water Associated Oil Company on completion of its Porter No. 1 in October, 1938, with initial daily production estimated at 1,000 barrels of oil. On a potential test the well flowed 1,200 barrels a day of 24.2° A.P.I. gravity, 0.7 per cent cut, 40/64″ bean, 150 pounds tubing pressure, 1,300 pounds casing pressure. Total depth is 5,393 feet. Producing from 598 feet of zone from 4,795 feet to bottom.

Development.—Three locations.

Geology.—Oil accumulation occurs in Middle Pliocene beds lying directly beneath what is presumed to be a north-dipping thrust fault. The structure of the producing beds beneath the fault is as yet unknown.

Geologic method of discovery.—Discovery was made on the basis of geologic field mapping.

NEW ZONES IN KNOWN OIL FIELDS

New producing zones were discovered in five fields during 1938, the most important of which was the Vedder zone of the Greeley field. New zones in two other fields, Torrance and Montebello, were rapidly developed and provided considerable areal extension of these older fields. A new zone in the Signal Hill area of the Long Beach field proved productive but not at a rate considered commercially profitable for its depth. The northwest extension of the Long Beach field (Hilldon area) obtained its first Miocene production by the discovery of a new and deeper zone.

GREELEY FIELD

The Vedder zone, lying 3,600 feet below the previously productive Greeley zone, was found to be capable of prolific production. This

discovery was made by the Standard Oil Company in June, 1938, on completion of its K.C.L. No. 11-2 at a depth of 11,520 feet. Initial daily production was 6,408 barrels of oil, 37° A.P.I. gravity, 0.1 per cent cut, 96/64″ bean, 375/0 pounds pressure, 4,855 M.c.f. of gas, flowing. The producing zone lies between 11,396 and 11,520 feet and is correlative with the Vedder zone (Lower Miocene) of the near-by Rio Bravo field.

TORRANCE FIELD

Considerable activity developed along the south flank of the Torrance field after the Chanslor Canfield Midway Oil Company completed its Torrance No. 33 in January, 1938, for 161 barrels of 27° gravity oil from the Del Amo (Miocene) zone. This zone had been previously discovered by the C.C.M.O. Company on their Del Amo lease, but production was not sufficiently large to encourage further development. On December 29, 1938, there were 166 wells producing 10,990 barrels of oil per day from the Del Amo zone. The depth is approximately 5,000 feet, and the gravity of the oil ranges from 22° to 30.2° A.P.I. Due to the close spacing of wells, the thinness of the zone, and the lack of proper curtailment, most wells have developed water troubles.

At the end of 1938 there were 36 wells producing a daily average of 3,481 barrels of oil in the Harbor City area of the Torrance field. The extension was due to the completion of the D. & B. Oil Company well No. 1 with an initial daily production of 663 barrels of oil, 29.5° A.P.I. gravity, 15 per cent cut, 40/64″ bean, 50–60/340 pounds pressure. The cut later reduced to 0.5 per cent. Total depth is 5,275 feet, producing from 155 feet of zone from 5,120 feet to bottom. The producing zone has an average thickness of 150 feet, approximately one half of which is oil sand.

MONTEBELLO FIELD

Three new oil zones were discovered at the western end of the Montebello field. Development of these zones provided considerable areal extension of the producing limits of the field.

Activity in this area was started by the discovery of the sixth zone by the St. Helens Petroleum Corporation in January, 1938, when it completed Monterey No. 20 for an initial daily production of 1,700 barrels of oil, 38° A.P.I. gravity, 1 per cent cut, 66/64″ bean, 500 pounds tubing pressure, 1,200 pounds casing pressure, 8,670 M.c.f. of gas, flowing. Total depth is 6,353 feet and production comes from 20 to 30 feet of sand in a 130-foot zone (Upper Miocene) between 6,221 and 6,353 feet.

Subsequent wells proved the existence of two additional zones, the fifth, a higher zone in the lower part of the Pliocene between depths of 5,400 and 5,800 feet, and the seventh, a lower zone in the Miocene between 7,000 and 7,200 feet. By the close of the year 32 wells with initial daily productions of between 250 and 3,300 barrels had been completed in one or more of these zones.

Production from these new zones is confined to the so-called West Montebello field and is believed to be trapped in this area by a northerly trending fault which cuts across the westward plunging Montebellow anticline.

LONG BEACH FIELD

A new deep zone of doubtful economic value was discovered in the Signal Hill area of the Long Beach field by the De Soto Oil Company. Its well No. 1 was completed in December, 1938, for an initial daily production of 250 barrels of oil, 28.0° A.P.I. gravity, 2.5 per cent cut, 43/64″ bean, 120 pounds tubing pressure, 540 pounds casing pressure, on compressor. Total depth is 10,157 feet with production coming from 398 feet of Miocene sand and shale between 9,710 and 10,157 feet.

NORTHWEST LONG BEACH FIELD ("HILLDON" AREA)

The northwest extension of the Long Beach field, discovered in 1937 by the Hilldon Oil Company, obtained its first Miocene production in July, 1938, when the Hilldon Oil Company completed its Dominguez No. 1 in a new zone between depths of 7,710 and 7,788 feet. Initial daily production was 840 barrels of 23.9° A.P.I. gravity oil, 0.1 per cent cut, 56/64″ bean, 1,700 M.c.f. gas, and 170 pounds casing pressure.

EXTENSIONS OF KNOWN OIL FIELDS

Extensions of known fields during 1938 have added an estimated 110 million barrels to the state's oil reserve. These extensions of previously discovered fields add nothing to the oil discovery column for 1938 (Fig. 6) but rather to the columns for the preceding years in which these fields were discovered. The reserves made apparent by these extensions together with those estimated for the new fields of 1938 constitute the total additions to reserves for the 1938 column of Figure 1.

WILMINGTON FIELD

The Wilmington field was extended one mile to the southeast, into the western edge of the City of Long Beach, by the completion of Superior Oil Company 1960 Community well No. 1 in January, 1938. Initial daily production was 3,917 barrels of oil, 23.6° A.P.I. gravity,

3.9 per cent cut, 60/64″ bean, 220 pounds casing pressure, 46/64″ bean, 60 pounds pressure. Total depth is 4,028 feet, plugged to 3,890 feet. This area, actively developed in the Terminal and Ranger zones during the first half of the year, added materially to the proved area of the field.

ROSECRANS FIELD

The O'Dea zone of the Rosecrans field, discovered in 1937, underwent continued active development during 1938. Potential and actual daily production, proved area, and known reserves for this zone were materially increased. Producing wells in this zone totaled 36 at the end of the year, most of which were characterized by large daily yields.

TORRANCE FIELD

The Torrance field experienced considerable extension southeastward during 1938 by reason of the discovery and development of a new and deeper oil zone. This new zone development is described on page 940 under the heading of new oil zones.

POTRERO FIELD

The Potrero field, a small and inactive Los Angeles Basin field immediately southeast of Inglewood, had one new completion in May, 1938, which may encourage further development. The Basin Oil Company's new well, Potrero No. 1, was capable of an initial daily production of 600 barrels of oil, 50° A.P.I. gravity, 1 per cent cut, 21/64″ bean, 375 pounds tubing pressure, 925 pounds casing pressure, 300 M.c.f. of gas, flowing. Total depth is 4,741 feet, plugged to 4,666 feet. Production was obtained by gun-perforating opposite a 10-foot Lower Pliocene oil sand between 4,628 and 4,638 feet. Success in this area is hindered by the close association of oil sands and water sand.

VENTURA AVENUE FIELD

Operators of the Ventura Avenue field have been successful during 1938 in extending the producing area of some of the deeper zones along the north flank of the central and eastern parts of the field. Depths of producing zones in more recent wells generally range between 8,000 and 9,000 feet. The Associated Oil Company completed its McGonigle No. 11 at a depth of 10,935 feet for 1,631 barrels of 29° gravity oil from 490 feet of zone.

WEST CAT CANYON FIELD

The West Cat Canyon field has long been comparatively inactive but in August, 1938, was extended one mile to the southwest on com-

pletion by the Standard Oil Company of its Las Flores well No. 1 in Sec. 27, T. 9 N., R. 33 W. Initial daily production was 450 barrels of gross oil, 14° A.P.I. gravity, 4 per cent cut, pumping. Total depth is 6,556 feet, plugged to 6,440 feet. The producing formation is Monterey shale. Due to the present limited demand for this quality crude no active development is expected to result from this extension.

OTHER FIELDS

Several of the more important fields discovered during the last two years have been extended by normal development during 1938. The most important of these are Canal, Rio Bravo, and Newhall-Potrero. Although these extensions were expected and call for no particular discussion here, they contributed materially to the quantity of oil reserves added during the year.

NEW GAS FIELDS

WILLOWS GAS FIELD

The Willows gas field, located along the west side of the Sacramento Valley, Sec. 18, T. 20 N., R. 2 W., 135 miles northeast of San Francisco, was discovered by the Ohio Oil Company on completion of its Willard No. 1A in August, 1938, with an initial daily rate of 5,356 M.c.f. of gas, through a 21/32″ bean, 515/600 pounds pressure. Total depth is 6,014 feet in Cretaceous, plugged to 2,247 feet. Production is obtained through perforations opposite a 10-foot Cretaceous sand between depths of 2,237 and 2,245 feet. The well is now shut in.

Accumulation in this area occurs in closed anticlinal structure discovered by use of the reflection seismograph.

POTRERO HILLS GAS FIELD

A fifth gas field was added to Northern California in December, 1938, when the Richfield Oil Corporation completed its Potrero Hills well No. 1 in Sec. 10, T. 4 N., R. 1 W., 40 miles northeast of San Francisco. The initial daily production was 5,000 M.c.f. of gas, through a 16/64″ bean, with 475 pounds tubing pressure and 990 pounds casing pressure. Total depth is 5,334 feet, plugged to 3,265 feet. Production is obtained from 40 feet of Cretaceous sand between 3,225 and 3,265 feet.

The discovery well was drilled on the axis of a prominent east-west trending anticline exposed in Eocene and younger Tertiary formations.

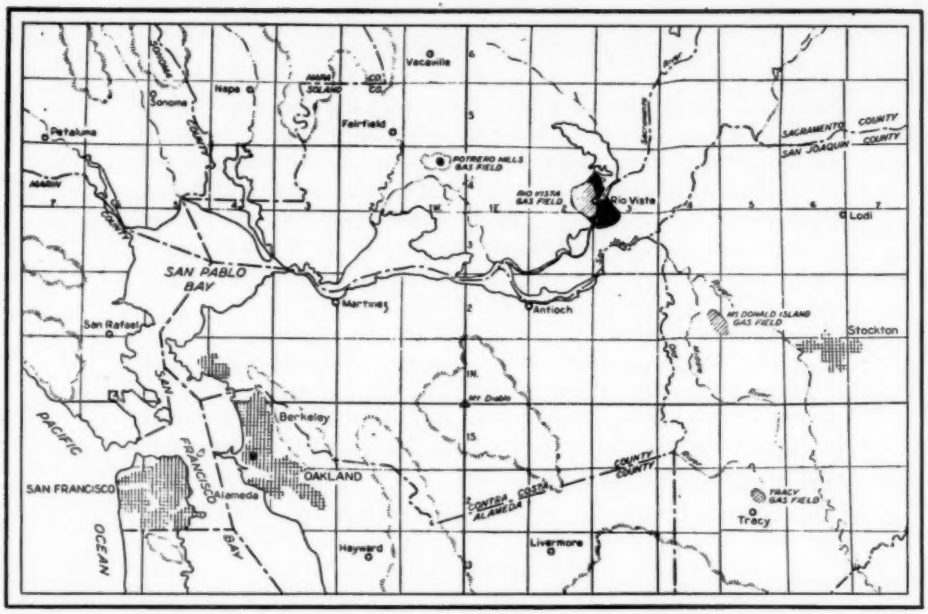

FIG. 5.—Gas fields of San Francisco-Stockton area showing new Potrero Hills field and extension of Rio Vista field in solid black.

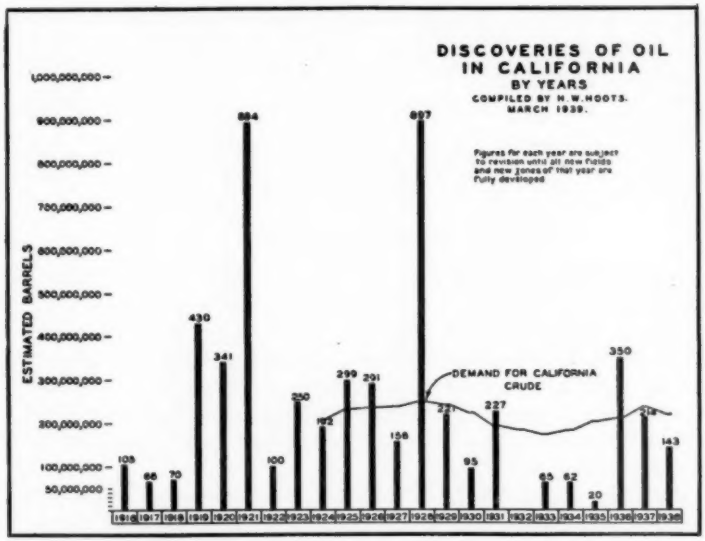

FIG. 6.—Discoveries of oil in California by years. Figures for each year are subject to revision until all new fields and new zones of that year are fully developed. See Figure 1 for list of discoveries in 1938. Demand figures for 1924–1937 inclusive are calculated on a two-product (crude and gasoline) basis while those for 1938 are on an all-product basis.

EXTENSION OF KNOWN GAS FIELDS

The Rio Vista gas field was extended 2½ miles to the southeast on the completion by the Standard Oil Company and The Texas Company of their Midland Fee No. 1 in July, 1938. The initial flow was at the rate of 24,443 M.c.f. of gas, 64/64″ bean, 1,025 pounds flow pressure. This field now contains about 9,000 proved acres and is the largest field producing only gas in the state.

RÉSUMÉ OF GEOLOGICAL DISCOVERIES

Geological discoveries of new fields and new zones in 1938 added an estimated 143 million barrels to the known oil reserve of the state (Fig. 6). Present estimates are conservative and will be annually increased by extended development of these new fields in future years. New oil reserves discovered in the preceding year, 1937, as estimated at the close of that year, amounted to 125 million barrels but have been increased by normal development during 1938 to an estimated 214 million barrels. Discoveries of earlier years have been increased by smaller amounts during 1938.

The East Coalinga Eocene field appears to be the most important discovery of the year. It is probable that this stratigraphic overlap with a known thickness of 587 feet of unusually permeable medium coarse oil sand will yield two or three times the quantity of oil that can be credited to it now with the present limited distribution of wells.

The Wasco field, discovered by the deepest well in the world, is probably small in area but is limited in estimated reserves primarily by the known presence of only 40 feet of oil sand.

The Coles Levee, Richfield-Western, and Aliso Canyon fields are all fields of at least moderate importance. Known thicknesses of oil and gas sand in these fields are 115 feet, 238 feet, and 245 feet, respectively, and in each case the discovery well stopped in oil sand.

GEOLOGICAL EXPLORATION AND WILDCAT DRILLING

Figure 7 shows a close correlation between the quantity of oil discovered and the combination of geological activity and wildcat drilling. The curve of wildcat drilling is declining and that for geological activity is tending to flatten. Continuation of these trends, if past experience is accepted as a reliable guide, should ultimately lead to a decline in the discovery rate. Past serious declines in the discovery rate, such as that during the period from 1931 to 1936, are obviously the result of a comparable decline in exploration activity.

Ninety-five per cent of the new discoveries in California are made by large companies supported by sizable and competent geological staffs. Few, if any, lucky accidents appear in the oil discovery record of the past 20 years and, during the last decade, only one sizable discovery has been made by an independent operator. This is due principally to the expense attached to adequate geological exploration and the drilling to depths now generally required.

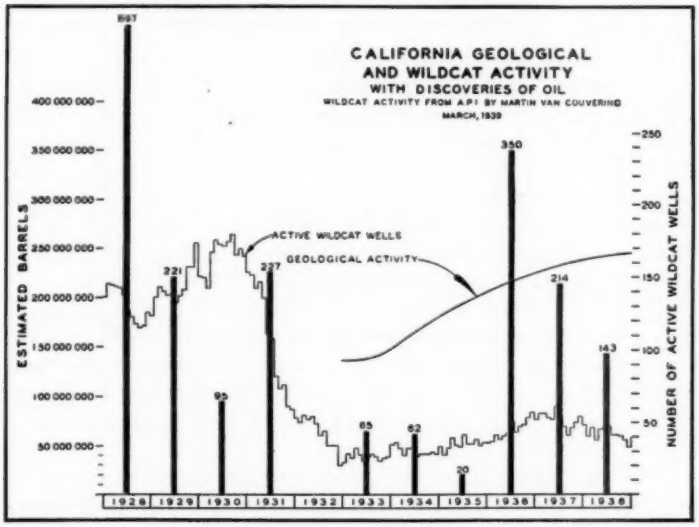

FIG. 7.—Geological and wildcat drilling activity compared with discoveries of oil.

The reflection seismograph continues to be an important, almost indispensable, tool in geological exploration in this state. This instrument under geological guidance accounted for three of the five new fields of 1938, while field and subsurface geology were responsible for the other two.

OVERPRODUCTION AND DISCOVERY RATE

The present rate of discovery of additional reserves, although keeping pace with consumption, should be improved in order to satisfactorily augment our decreased reserve supply. The rapidity of drilling wells in new fields and the resulting excessive production or capacity to produce is now interfering with normal exploration and a desirable rate of discovery.

California for more than a year has faced an overproduction situ-

ation of such magnitude as to seriously threaten profitable operation. Production has been rapidly filling available storage and the greatly increased capacity to produce has required that the maximum daily

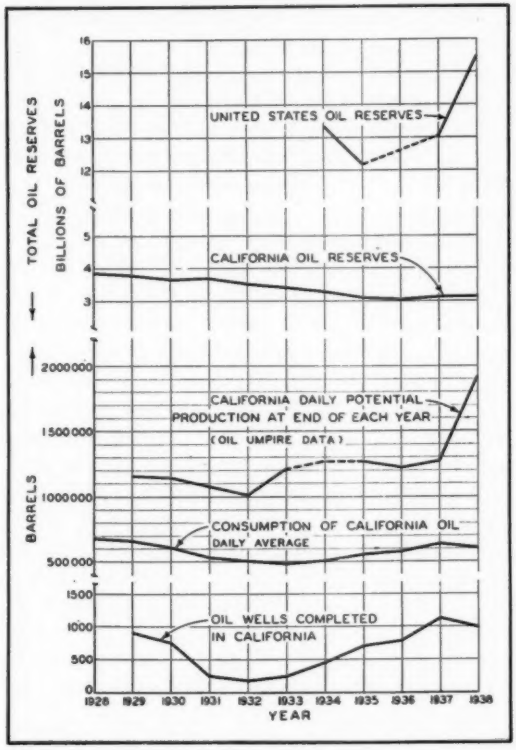

FIG. 8.—Comparative curves showing (1) that California oil reserves, although considerably lower than 10 years ago, have been increasing slightly for the past 2 years; (2) that increase in oil reserves during the last two years corresponds to a general increase in consumption; and (3) that the number of wells completed annually during the last 6 years has increased from 184 in 1932 to 995 in 1938, and that the potential production developed in the last year far exceeds the quantity necessary to meet present requirements as indicated by the consumption curve. (Figures on United States principally from American Petroleum Institute.

allowable for new wells be cut in half. This condition exists in spite of the fact that new discoveries in terms of total reserve supply have not been excessive in any year during the last decade.

Overproduction does not necessarily result from the discovery of new fields but rather from the drilling of an excessive number of new

wells in these new fields and the insufficient curtailment of their production. The curves of Figure 8 offer comparisons between reserves of California and the United States, between California reserves and demand, between potential production, number of new producing wells completed, and demand, and between California reserves and the number of new producing wells.

It is clear that the estimated capacity to produce has been developed far in excess of daily requirements of about 600,000 barrels and, during the past year, has almost doubled in spite of a 15 per cent reduction in the number of wells completed. It is equally clear that the ability to produce is developed independently of the discovery of new reserves, the yearly average of which for the last three years is almost identical with the average annual demand.

The success of discovery during the last three years has vastly improved over that for the preceding four years and is due largely to improved technique in exploratory methods and a constructive attitude toward the necessity for additional reserves.

Increasing demand for oil and the relatively low position of our total known oil reserves require that continuous effort be expended to improve on the encouraging but moderate success of the last three years and on the technique of finding oil. The time factor invariably associated with the necessary research for, and the practical application of, new exploratory methods, together with the loss of efficiency in discontinuous effort can not be over-emphasized.

Continuation of exploration for new reserves is essential but is periodically discouraged by excessive daily supply and attendant threats to price structure. Decline in exploration commonly continues until the supply dwindles and a shortage is threatened. The cycle of renewed exploration, discovery, and the development of excessive production then begins anew.

Any change in present conditions which will lead to less violent fluctuations in this cycle and greater stability throughout the industry is desirable. This may be accomplished by increased curtailment of production or relief from the requirement to drill and produce during periods of threatened over-supply. Under the resulting more stabilized conditions exploration for needed additional reserves can proceed with greater efficiency.

ACKNOWLEDGMENTS

The writer is indebted to many California geologists for their coöperation in providing data, to W. R. Wardner of the California oil umpire office for statistics, to M. E. Tracy of the Richfield Oil Corporation for figures on 1938 demand, and to Mrs. Daisy Hansen for assistance in compiling.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE, 1939), PP. 949-967, 2 FIGS.

FOREIGN OIL DEVELOPMENTS IN 1938[1]

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INTRODUCTION

The complete summary of the crude oil production of the world is presented in Table I which shows by countries the total annual and average daily production for 1937 and 1938, per cent change in 1938 as compared with 1937, and the participation of each country in the world's total production in 1938.

TABLE I
CRUDE-OIL PRODUCTION OF THE WORLD

	1937		1938			
	Total TB	*Average Bbl./Day*	*Total TB*	*Average Bbl./Day*	*Per Cent Change from 1937*	*Per Cent of World Production*
U.S.A.	1,279,160	3,504,548	1,213,254	3,323,984	− 5.15	60.736
U.S.S.R.	212,742	582,855	224,714	615,655	+ 5.63	11.249
Venezuela	186,654	511,381	190,232	521,184	+ 1.92	9.523
Iran	76,590	209,836	77,230	211,589	+ 0.84	3.866
Neth. East Indies	54,900	150,411	55,120	151,014	+ 0.40	2.759
Roumania	51,859	142,079	47,850	131,096	− 7.73	2.395
Mexico	46,738	128,049	36,000	98,630	− 22.98	1.802
Iraq	31,900	87,397	32,100	87,945	+ 0.63	1.607
Colombia	20,298	55,611	21,582	59,129	+ 6.33	1.080
Trinidad	15,503	42,474	17,737	48,595	+ 14.41	0.888
Argentina	16,357	44,814	16,937	46,403	+ 3.55	0.848
Peru	17,467	47,855	15,839	43,395	− 9.32	0.793
British India and Burma	9,850	26,986	9,865	27,027	+ 0.15	0.494
Bahrein Island	7,762	21,266	8,298	22,734	+ 6.91	0.415
Sarawak and Brunei	6,053	16,584	7,012	19,211	+ 15.84	0.352
Canada	2,995	8,206	6,947	19,033	+ 131.95	0.349
Greater Germany	3,538	9,693	4,397	12,047	+ 24.28	0.220
Poland	3,705	10,151	3,820	10,466	+ 3.10	0.191
Japan	2,490	6,822	2,550	6,986	+ 2.41	0.128
Ecuador	2,160	5,918	2,260	6,192	+ 4.63	0.113
Egypt	1,141	3,126	1,515	4,151	+ 32.78	0.076
Saudi Arabia	65	178	495	1,356	+ 661.54	0.025
Hungary	14	38	365	1,000	+2,507.14	0.018
Others	1,408	3,858	1,460	4,000	+ 3.69	0.073
Total	2,051,349	5,620,136	1,997,570	5,472,822	− 2.62	100.000

The brief reviews of individual countries, arranged in order of current magnitude of production, discuss the more pertinent developments of the past year and, where possible, suggest the outlook for the coming few years on the basis of available geological information.

In general 1938 was marked by major political and economic uncertainties throughout the world which have necessarily retarded or

[1] Read before the Association at Oklahoma City, March 23, 1939. Manuscript received, April 15, 1939.

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have even completely checked the development of old fields and the exploration of new areas in several countries. These developments are not discussed further in this paper which is limited to a review of newly obtained and released geological data.

U.S.S.R. (RUSSIA)

There were no discoveries of importance made in the U.S.S.R. in 1938. Failure to open new fields during the past year in Russia was due primarily to a marked slowing down of wildcat operations due to technical difficulties and not to the lack of promising prospects. On the contrary the progress of geological and geophysical exploration work was most satisfactory and a number of major structural features have been mapped and are ready for drilling.

On the Apsheron Peninsula in the Baku district early in 1939 an apparently major oil field was discovered in the Yassamal Valley on the southeast flank of the Atashka Mountain elongate anticline. This anticline is of "diapiric" type with Miocene exposed on the apex of the structure and highly faulted beds of upper "Productive measures" of Pliocene truncated and cropping out around the Miocene core. The lower strata of the "Productive measures" are overlapped on this structure by the upper zones of the same series and hence form favorable trap for the accumulation of crude oil. On this structure the outcropping sands of the upper "Productive measures" are highly saturated with heavy crude oil and in this area is located the small Shubani field, one of the oldest on the Apsheron Peninsula, producing heavy crude oil from hand-dug wells and from shallow borings. The Shubani field has produced to date about 5,000,000 barrels and is making currently about 450 barrels per day. The new discovery was made in January, 1939, on the southeast flank of the Atashka structure in the Yassamal Valley (Fig. 2) by well No. 631 producing initially 2,200 barrels per day from the Sub-Kirmaku section of the lower "Productive measures" truncated against the structure below the surface. Inasmuch as the exposed sands of the upper "Productive measures" are highly saturated with oil but have lost most of their producible oil through evaporation and seepage it may be anticipated that the Yassamal discovery will prove to be of major importance, the oil in the sands of the lower "Productive measures" having been effectively sealed by overlying sands and shales of the younger overlapping members of the "Measures." This discovery is most important regionally since a number of similar structures exist on the Apsheron Peninsula and further detailed exploration of the flanks of the known "diapiric" anticlines with indi-

MAP LEGEND FOR FIGURE 1

(Showing year of discovery of oil fields)

KUBAN-MAIKOP DISTRICT

1. South Varenikovo prospect (adjacent to active Shugo mud volcano)
2. North Varenikovo prospect
3. Adaghum oil field—1936
4. Keslerovo oil field—1936 (first explored in 1885)
5. Kudako oil field—1866
6. Kutaiski oil field—1912
7. Kura Tzetze oil field—1937
8. Shirokaia Balka oil field—1937
9. Asphalt Mountain oil field—1936
10. Khadijenski-Apsheron oil field—1908
11. Suvorovo-Cherkess oil field—1914

GROZNY DISTRICT

a. Kumo-Sulak trend of gas seepages, probably associated with a major anticlinal trend
b. Edessi anticline
c. Terski anticline
d. Sunjenski anticline

1. Malgobek oil field—1934
2. Voznesenski oil field—1915
3. Gorski Mountain oil field—1937
4. Taimaz Kala—Mujim Buru prospects (large gas wells)—1936
5. Old Grozny oil field—1893
6. New Grozny oil field—1913
7. Gudermes oil field—1938
8. Benoi oil field—1930
9. Achi Su oil field—1935
10. Izberbash oil field—1936
11. Kaia Kent oil field—old shallow hand-dug wells—new 1932
12. Berekei-Duzlak-Dagestanski Ogni prospects (Berekei produced about 600,000 barrels between 1902 and 1913; not producing now but undergoing further exploration. Gas wells and hot-water gushers are typical of this fold)

GEORGIA DISTRICT

1. Taribani prospect
2. Mirzaani oil field (old shallow hand-dug wells)—1927
3. Little Shiraki oil field (old shallow hand-dug wells)

KURA DISTRICT

1. Pirsagat oil field—1935
2. Khydyrly-Biandovan prospect
3. Nefte Chala oil field—1926

EMBA SALT DOME DISTRICT (approximately 250 salt domes have been found in this district)

1. Iskine oil field—1933
2. Dossor oil field—1911
3. Makat oil field—1915
4. Baichunas oil field—1931
5. Bisbuliuk prospect
6. Sagiz oil field—1933
7. Koschagil oil field—1935
8. Munaili prospect
9. Djaksibai oil field—1936
10. Shubarkuduk oil field—1933

MIDDLE VOLGA — STERLITAMAK — PERM DISTRICT

Tentatively Projected Major Structural Trends

I Kotelnich Anticline
II Siktivan—Kirov—Cheboksari Anticline
III Polometz-Urjum Anticline
IV Glazov-Ulianovsk Anticline
V Perm-Jiguli-Kuznetsk Anticline
VI Ishimbaevo Anticline
VII Sizran Anticline

1. Zaborov prospect
2. Sizran oil field—1937
3. Troekurov prospect
4. Yablonovi Ovrag oil field—1937
5. Zolny Ovrag prospect
6. Vodin prospect
7. Novo-Stepanovsk prospect
8. Buguruslan oil field—1937
9. Ardatov prospect
10. Touimaz oil field—1937
11. Ishimbaevo oil field—1932
12. Polometz gas field—1938
13. Krasnokamsk oil field—1936
14. Chussovskie Gorodki oil field—1929

TURKMEN DISTRICT

1. Cheleken Island oil field—1873
2. Neftedag oil field—1931

UZBEK TADJIK DISTRICT

1. Sel Rokho "Kim" oil field; old Santo —1909
2. Nefteabad oil field
3. Shor-Su "Kaganovich" oil field—1927
4. Yarkutan oil field—1904
5. Chimion oil field—1904
6. Changirtash oil field
7. Maili Sai-Barzik-Enku-Shing-Kulmen prospects (Maili Sai produced a little oil in 1903)
8. Khaudag oil field—1934

SAKHALIN DISTRICT

1. Okha oil field—1923
2. Ekhabi prospect
3. Boatsin prospect
4. Katangli prospect
5. Nabil prospect

PROSPECTIVE AREAS WITH EXPLORATION UNDER WAY

A. Crimean Peninsula
B. Melitopol district
C. Stalingrad district
D. Saratov district
E. Ukhta district
F. Lake Baikal district
J. Kamchatka (Bogachevsk) district

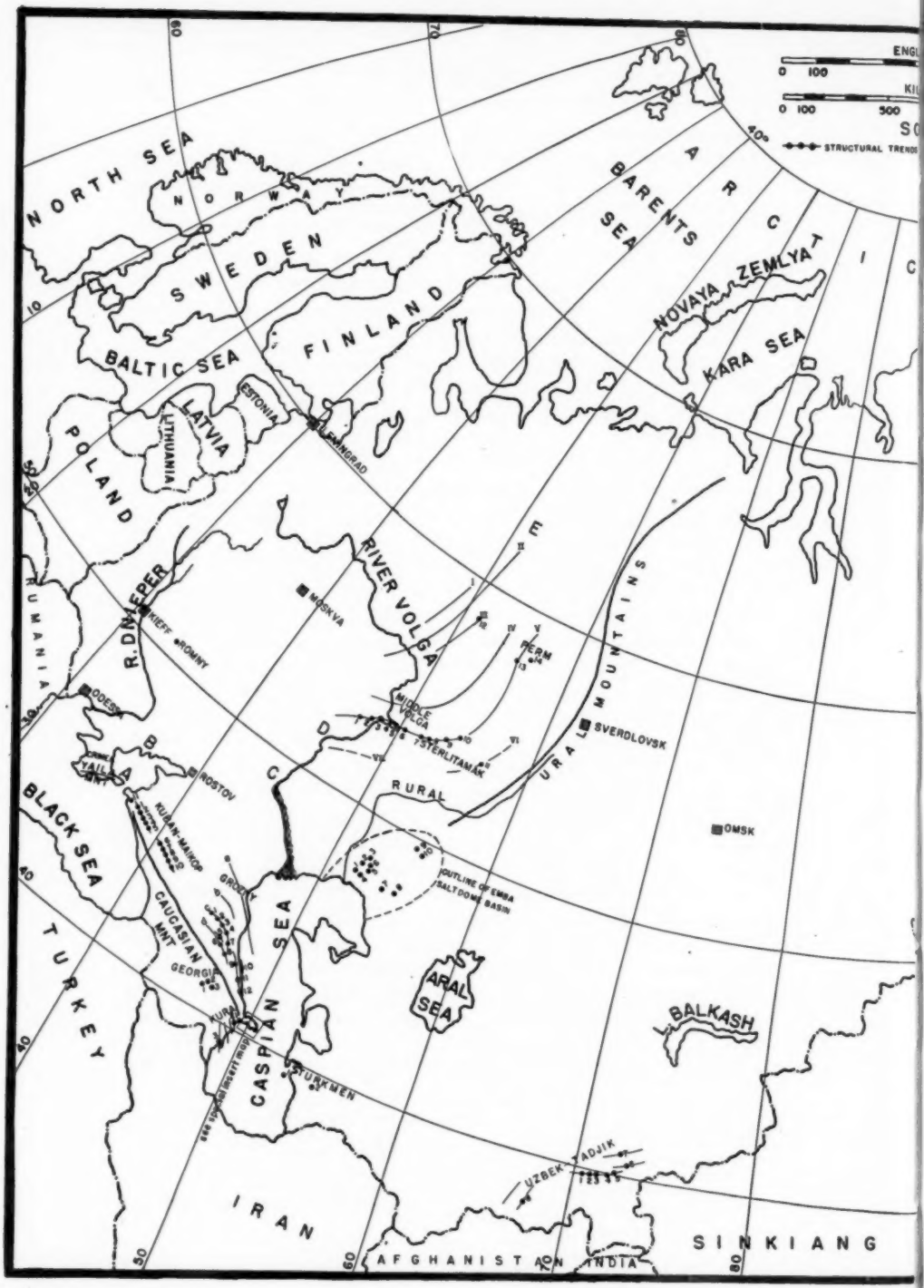
NORTH SEA
NORWAY
SWEDEN
FINLAND
BARENTS SEA
ARCTIC
NOVAYA ZEMLYA
KARA SEA
BALTIC SEA
ESTONIA
LATVIA
LITHUANIA
POLAND
LENINGRAD
RUMANIA
R. DNIEPER
KIEFF
ROMNY
MOSKVA
RIVER VOLGA
MIDDLE VOLGA
PERM
TSYERLITAMAK
URAL MOUNTAINS
SVERDLOVSK
ODESSA
YALTA
ROSTOV
RURAL
OMSK
BLACK SEA
KUBAN-MAIKOP
GROZNY
CAUCASIAN MNT
GEORGIA
OUTLINE OF EMBA SALT DOME BASIN
CASPIAN SEA
ARAL SEA
BALKASH
TURKMEN
UZBEK
TADJIK
TURKEY
IRAN
AFGHANISTAN
INDIA
SINKIANG
STRUCTURAL TRENDS

FIG. 1

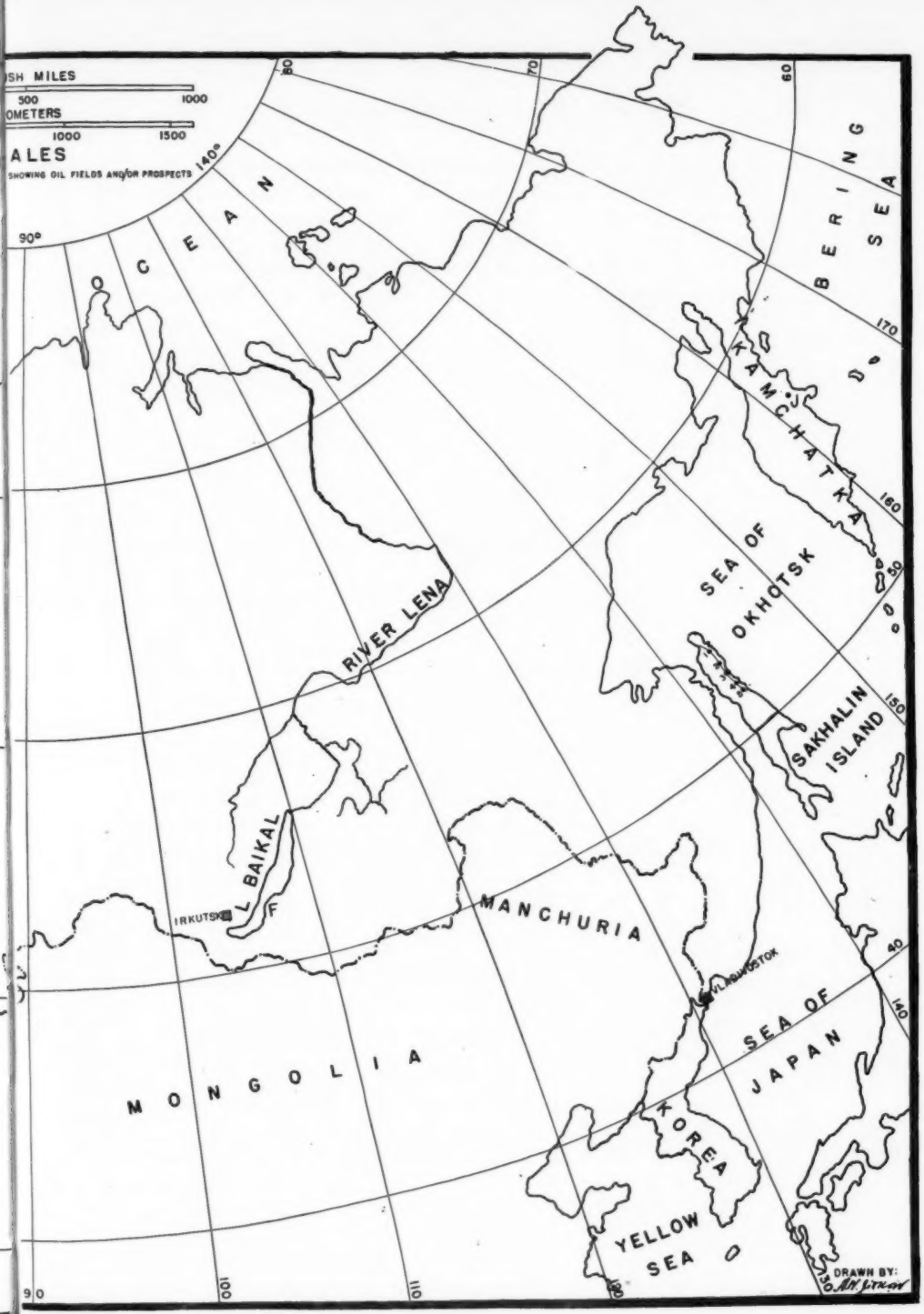
SH MILES
500
1000
OMETERS
1000
1500
ALES
SHOWING OIL FIELDS AND/OR PROSPECTS
OCEAN
BERING SEA
KAMCHATKA
SEA OF OKHOTSK
RIVER LENA
SAKHALIN ISLAND
L BAIKAL
IRKUTSK
MANCHURIA
VLADIVOSTOK
SEA OF JAPAN
MONGOLIA
KOREA
YELLOW SEA
DRAWN BY:

FIG. 1

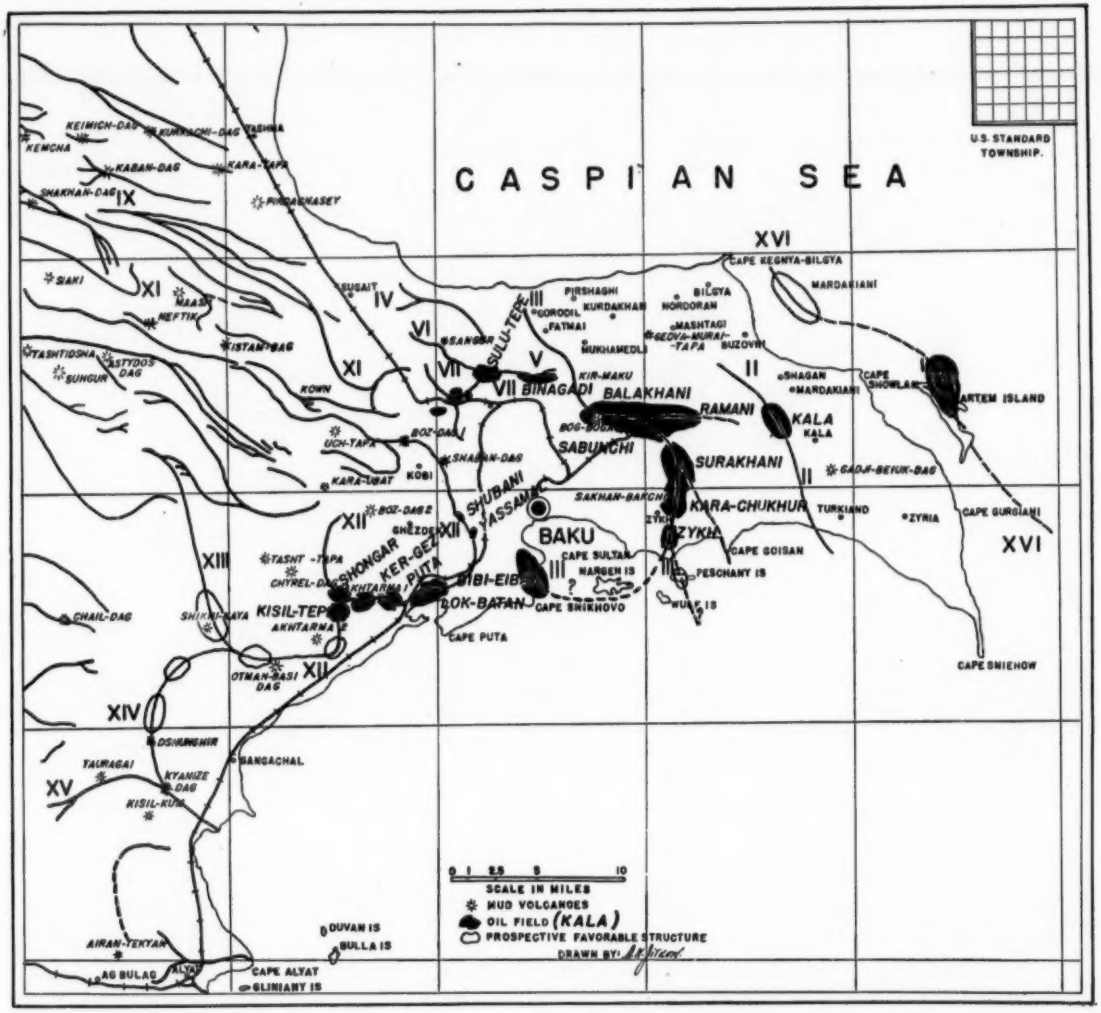

FIG. 2.—Map of Apsheron Peninsula, showing location of oil fields. Figure 1 shows location of Peninsula.

cated overlaps within the "Productive measures" will be undoubtedly undertaken. The stratigraphic importance of such discoveries will be greatly accentuated by the fact that a number of these folds are within a few miles from older fields, thereby facilitating their exploration and exploitation. Russian geologists deserve considerable credit for beginning to solve the problem of flank overlap accumulation on highly complex faulted structures of "diapiric" type.

Several older fields of the Apsheron Peninsula were enlarged during 1938 but the only major addition to the proved acreage was made in the Bibi Eibat field (Fig. 2) which was extended northwest with the producing area now reaching in that direction over the high escarpment of the Apsheron limestone, the uppermost member of the Pliocene. In other fields of the peninsula only minor areal and vertical extensions were made with the result that Baku area was barely able to maintain its 1937 rate of output, the district producing 164,250,000 barrels in 1937 and 164,692,000 barrels in 1938. It is anticipated that the fields of the Apsheron Peninsula will continue to produce at about the present rate for a considerable number of years with only a routine number of discoveries and extensions to older fields and that if the new developments on the flanks of the "diapiric" folds prove to be of major importance the peninsula will be able to increase appreciably its current rate of production. The other possibility of increasing the production from the Baku district appreciably is the discovery of oil on the Mardakiani structure located offshore in the Caspian Sea northeast of the peninsula on the Artem Island trend (Fig. 2). On this structure, however, the "Productive measures" are apparently extensively truncated and much of its oil might have escaped unless the lower sands of the "Measures" have either escaped being drained by faulting or, as is the case with Atashka Mountain, have been sealed by overlapping which on this flatter type structure does not appear likely.

There were no discoveries of any consequence during 1938 in the area north of the main Caucasian ridge. The Grozny fields have been and are very rich in gas, many having large gas caps; but, with considerable premium placed on the production of crude oil, billions of cubic feet of gas have been and are being blown and burned in flares to produce only a few additional barrels of oil. Such practice obviously wastes not only the natural-gas fuel which is not generally used by the local industries or even refineries but also dissipates the lifting energy of the crude oil and permits rapid and uneven water encroachment, thereby greatly reducing ultimate recoveries. Since a number of newer fields in Grozny district, such as Gorski, are primarily gas

FIG. 2.—Map of Apsheron Peninsula, showing location of oil fields. Figure 1 shows location of Peninsula.

fields comparable with Kettleman Hills or Cotton Valley in the United States, the waste of gas and oil under prevailing practices is enormous. The Grozny district will continue to decline in production in the coming years unless new large fields are discovered on the Edessi, Kumo-Sulak, or other structural trends paralleling, and due north of, the Terski and Sunjenski anticlinal trends now producing, as shown in Figure 1.

In the Maikop-Kuban district there were no discoveries in 1938 but the continued development of known fields has resulted in an appreciable increase of production from 10,000,000 barrels in 1937 to 13,500,000 barrels in 1938. This district is situated most favorably with a number of pinching-out shoreline sand bodies found at shallow depths and is near industrial and export points and it will undoubtedly continue to gain in importance in the coming years and may feasibly become the third major producing province in the U.S.S.R. following the Apsheron Peninsula and the Ural-Volga Permian basin.

By far the most interesting and important area of the U.S.S.R. now being pioneered is the Ural-Volga Permian basin. While there were no field discoveries made in this vast area during the past year much was achieved in this unquestionably major oil-producing province of the world in an interpretive way. Principal structural trends extending for as much as 1,000 miles, shown in Figure 1, have been recognized and additional structures on those trends have been actively detailed. During 1938 this province accounted for 14,435,000 barrels as compared with 9,700,000 barrels produced in 1937 and the third 5-year plan just announced anticipates production of 60,000,000 barrels in 1942, a volume which may be easily exceeded if the refining developments keep up with the discoveries and the industry can absorb a large volume of high sulphur-content crude since even currently the fields are being periodically shut down for the lack of storage facilities at the refineries at which high sulphur-content heavy fuel oils accumulate and fill up all the available tanks. It is estimated by the Soviet geologists that the definitely proved oil reserves of the Ural-Volga district now amount to 1,100,000,000 barrels and that an additional large reserve is probable in already detailed structures ready to be tested by the drill.

The crude oil in the Ural-Volga Permian district is found in the formations of Permian, Carboniferous, and Devonian, with the principal production now being derived from the limestones of the Lower Permian. In the Ukhta district (*E* in Fig. 1) some oil is found in the outcropping formations and in shallow wells in the Devonian, and, since the Devonian formations are thought to underlie

most of the Ural-Volga Basin, sandstones and limestones of that age constitute a prospective major reserve. Farther south in the Krasnokamsk field the principal production is found in the Martyanian limestones of Carboniferous age at depths ranging from 3,000 to 3,100 feet, with secondary showings in the Kungurian dolomites of the Lower Permian at approximately 5,550 feet. The main producing section of Martyanian limestone in this field reaches 130 feet in thickness and the crude oil from it averages about 35° gravity with 36 per cent of lighter fractions. The structure is a northeast-southwest trending anticlinal feature with very gentle dips, the accumulation of oil apparently being controlled by the porosity of the limestone. Near Krasnokamsk is the unimportant Chussovskie Gorodki field in which the oil accumulation is in the upper Uralian limestones of Lower Permian (?) age encountered at 800–1,300 feet. In the Bashkir Sterlitamak district is located the Ishimbaevo field which is at this time the most important pool of the province and is now producing about 35,000 barrels per day. The oil in Ishimbaevo is found in the Kungurian limestone at an average depth of 3,300 feet, the producing section varying between 160 and 1,000 feet in thickness. The initial production of the wells is as high as 6,000 barrels, averaging 750 barrels per day, the oil is of 30° gravity with a sulphur content of 2.25 per cent and averages 44 per cent in lighter fractions. In the area of Ishimbaevo, possibly on a parallel anticlinal trend, other promising structures have been discovered in 1937 and 1938, including Buguruslan, Novo-Stepanovsk, Touimaza, and Ardatov. Production has been definitely proved by drilling at Touimaza and Buguruslan in 1937 and these two fields are now undergoing active drilling campaigns.

In the Jiguli district where the Volga River makes a great hairpin bend some production has been developed on several structures of this major anticlinal axis which is responsible for the bend and this area is now being actively developed and should become an important producing district. The first discovery in this area was made in Syzran, the oil being found in this field at about 3,300 feet in thin Turmaisian sands of the Lower Carboniferous. As can be seen in Figure 1, the structural axis of the Jiguli Hills apparently crosses the Volga River toward the east and then turns north toward Krasnokamsk. The projections of the structural axes as shown in Figure 1 are necessarily tentative and more exploration work is necessary before accurate interpretation will be possible. Elsewhere in Russia no discoveries or extensions to older fields were made, the development of Emba, of central Asia, of Turkmen and of Sakhalin Island being limited to routine drilling.

In general, while the U.S.S.R. possesses undoubtedly great undiscovered reserves, much of which could be easily reduced to proved classification by efficient wildcatting, the country very definitely has not blocked out a sufficient reserve to sustain the present rate of production under generally accepted conservation practices. The most important phase of the problem is that under present methods of production it is obviously impossible to plan the output of crude oil for any length of time since the flush fields skyrocket into prominence only to decline as precipitately within a few months. It is to be hoped that new fields to be discovered in the U.S.S.R. will not be allowed to waste their gas energy and will be drawn upon more conservatively than the older fields have been and will be able to increase their recoveries, permitting longer-term planning and reducing the production costs.

All factors considered it is anticipated that the U.S.S.R. will be able to maintain the present rate of production of between 600,000 and 650,000 barrels per day for the next 2 years and if during that period of time reasonably normal conditions prevail the country's production may average 800,000 barrels per day during 1941.

VENEZUELA

During 1938 the production in Veneuzela averaged 521,184 barrels per day as compared with 511,381 barrels in 1937. In western Venezuela the Lake Maracaibo district, producing from shoreline sands of Miocene age, continued to supply the greatest proportion of the production, accounting for 72.9 per cent of the total during the past year. In this area the Lagunillas field, although declining, remained the most important, averaging throughout the year about 185,000 barrels per day, and in this field 97 additional wells, all inside locations, were completed during 1938. The greatest activity in the Lake Maracaibo district was in the Tia Juana field, first developed in 1937. In this pool 171 wells were completed in 1938 and the production by the end of the year reached about 140,000 barrels per day. In the La Rosa field 46 wells, all inside locations, were completed during 1938 and the field has averaged during the year about 71,500 barrels per day. The most important development in the Lake Maracaibo district was the extension of the Lake fields toward the south by the very active drilling campaign in the Bachaquero field, really a southern extension of the Lagunillas field, which though discovered 9 years ago was not actively developed until last year. In Bachaquero 25 wells were drilled during 1938 and the production of the field reached 10,000 barrels per day by the end of the year. The field is slated for a rapid

drilling program during 1939 and should be the most active spot in Venezuela for 2 or 3 years to come. In the Mene Grande field, producing from Miocene sands on a north-south trending anticline, 51 wells were completed and the production from this field has averaged about 34,500 barrels per day in 1938. There were no developments of consequence in the smaller fields of western Venezuela and the new exploration work is being confined to the small extensions of the Lake fields farther in the Lake and to important tests now drilling in the Mene Grande field to the Eocene and in the Rio Tarra field to the Cretaceous.

Eastern Venezuela continued to make rapid strides during 1938 and has definitely become a major oil province. Quiriquire, producing from lenticular sands of Pliocene on a faulted monocline, continued to be the principal field in this area, averaging throughout the year about 70,000 barrels per day, 41 producers having been completed in this field during 1938. The Quiriquire field was extended somewhat toward the east during 1938 with a slight increase in its reserve. The Temblador field, discovered prior to 1938, began commercial shipments during that year, averaging in November 7,600 barrels per day. Thirty-nine wells were drilled in Temblador in 1938 and the field has now been proved in a narrow strip for a length of 16 miles. In the Oficina field, which has all the indications of becoming a major producing area, 6 rigs were running at the end of the year and a pipe line from Oficina to Guanta on the Caribbean is now under construction with shipments from this field scheduled to start in the autumn of 1939. An extensive exploration campaign has been undertaken in eastern Venezuela and undoubtedly will be continued in the coming years. During 1938 apparently commercial oil fields of as yet indefinite importance were discovered at El Tigre and at Jusepin. A small pumping well was completed at Merey. Dry holes were drilled during the year at Maturin, Algarrobo, and Snata while drilling is now under way at Santa Ana, El Roble, San Joaquin, Indios, Asceital, and Cerro Negro. In several of the indicated exploratory wells very favorable indications have already been obtained.

It is believed that during the coming few years western Venezuela will be just about able to maintain its current rate of production, compensating for the decline of the older fields with routine new development and it is almost certain that eastern Venezuela will be capable of greatly increasing its current rate of production, more particularly upon completion of new pipe-line outlets. It can be anticipated therefore that the production of Venezuela may gradually reach between 650,000 and 750,000 barrels per day within 2 or 3 years.

IRAN

Haft Kel continued to be the principal field of Iran, producing from the Asmari limestone of the Oligocene and it was reported during the year that the underlying Eocene limestone has also been proved to be productive in this field. Nothing of importance occurred during 1938 in the Masjid-I-Sulaiman field. The Gach Saran field, located 125 miles southeast from Haft Kel, was further outlined during 1938 and the tentatively proved area is now estimated as being 20 miles long and in places 5 miles in width, undoubtedly constituting a major reserve. Very promising results have been obtained in an exploratory well at Agha Jiri, 55 miles southeast from Haft Kel and 70 miles northwest from Gach Saran. Southeast from Agha Jiri at Pazanum a deep gas field was discovered. At Lali, 20 miles northwest from Masjid-I-Sulaiman, 1,200 feet of Asmari limestone was tested with negative results.

Iran undoubtedly possesses reserves of major magnitude but its production will depend primarily on the available market outlets.

NETHERLANDS EAST INDIES

Nothing of importance took place in the Netherlands East Indies last year and the production from these islands continued unchanged in 1938 at about 155,000 barrels per day. The generally declining trend of production in the older fields has been offset within the last 2 years by appreciable increases in Djambi district of South Sumatra and more particularly by greater production in the Kawengan district of Java, which averaged 5,800 barrels per day in 1936 and about 14,600 barrels per day in 1937 and in 1938. New Guinea began to attract more and more attention with the discovery of oil-saturated silts in the Miocene and an active geophysical exploration campaign is now under way by several companies.

ROUMANIA

The Roumanian oil fields averaged 131,096 barrels per day during 1938 as compared with 142,079 barrels in 1937, a decline of 7.73 per cent. This decline followed a drop of 18 per cent in Roumanian production in 1937 under 1936, indicating that the fields are very definitely suffering a major and continuous decline. The only favorable developments in Roumania during 1938 were in the Bacoi-Tintea and the Ceptura fields. In the Bacoi-Tintea field the deep Meotic sands at about 7,400 feet proved to be of major importance and the field increased its production from 1,180,000 barrels in 1937 to 4,310,000 barrels in 1938, an increase of about 265 per cent. At the

end of the year there were 15 wells drilling to the Meotic in this field but a further increase in its production is not anticipated. The Ceptura field produced in 1938 about 4,900,000 barrels as compared with 2,480,000 barrels in 1937, an increase of about 100 per cent, due to the development of the north flank but by the end of the year this drilling campaign was nearly completed and a marked decline is anticipated in the production of Ceptura in 1939. The Gura-Ocnitzei field just about maintained its production in 1938, producing 10,880,000 barrels in 1938 as compared with about 10,975,000 barrels in 1937. The Boldesti field suffered a decline of 26 per cent in 1938, producing 7,180,000 barrels as compared with 9,680,000 barrels in 1937. The Moreni field production dropped from 7,060,000 barrels in 1937 to 6,020,000 barrels in 1938. Piscuri, which may be considered as an extension of the Moreni field, produced in 1938 3,400,000 barrels as compared with 2,940,000 barrels in 1937 and the Bucsani produced in 1938 only 2,750,000 barrels, a decline of 38 per cent under the production of 1937. A major decline was suffered by Ochiuri where production fell from 3,000,000 barrels in 1937 to 2,390,000 barrels in 1938. There were no developments of importance in other fields of Roumania and none is indicated. Extensive drilling campaigns took place in 1938 only in the Bacoi-Tintea, Ceptura, and Moreni fields. There were no discoveries of any importance made in Roumania in 1938 and of the 10 important wildcats drilled on known structures only 2 small discoveries of questionable importance were made, at Draganeasa and at Magureli. In the older and currently producing provinces of Ploesti and Bacau there is but little prospect of making important discoveries or of extending the older fields and hence it is believed that the production of Roumania will continue to decline sharply, probably dropping to about 110,000 barrels per day during 1939 and possibly to 75,000 barrels per day within 2 or 3 years. Revision of the mining laws which have handicapped exploration in the past few years has been anticipated for early 1939 but the political developments of the last few months do not suggest that much new work will be undertaken.

MEXICO

Following the nationalization of all foreign properties in Mexico and loss by that country of established export outlets the production declined from an average of 128,000 barrels per day in 1937 to 98,600 barrels in 1938, a decline of 22.98 per cent. There was no new exploration work of any consequence conducted in Mexico during 1938 and hence the present reserves will have to be drawn upon until geological,

geophysical, and wildcat drilling work is again resumed. The Poza Rica field remains the only major proved reserve of Mexico and probably will be drawn upon extensively by the Mexican Government because of the ease of production and good quality of oil and it is anticipated that the older fields will be neglected with consequent appreciable loss in their ultimate recoveries. With very large reserve, possibly in excess of 500,000,000 barrels, remaining in Poza Rica, Mexico is in position to produce at a rate of about 50,000,000 barrels annually for a number of years, provided markets can be found for such a volume.

IRAQ

All exportable oil of Iraq continued to be produced from the Kirkuk field, though a little oil is produced for local requirements in the Naft Khanea field. Outside of the Kirkuk and Naft Khanea fields no commercial oil has been found to date in Iraq, though several structures are known to contain black oil ranging in gravity from 12° to 19°, with a sulphur content of 6–12 per cent, which can not be marketed and which is used only as road oil. The black oil produced ranges from Miocene to Upper Cretaceous in age, and on the B.O.D. concession 2 tests have been drilled to the Jurassic and at the end of 1938 one well was drilling in the Paleozoic at 9,012 feet. Exploration campaign continued in Iraq throughout 1938 and will continue in the coming years to fulfill the terms of the various concessions in force. Geological survey has started on the 37,000-square mile concession granted to the Basrah Petroleum Company in 1938, the only remaining part of the kingdom which has not been under concession.

Production in Iraq should continue at about the present rate for the next few years, being limited by the available pipe-line outlets.

COLOMBIA

During 1938 all production in Colombia has been derived from the Infantas and La Cira fields of the Tropical Oil Company on the De Mares concession. In La Cira field an important test to the Cretaceous was drilling at 7,983 feet at the end of the year.

The Barco concession which did not have an outlet prior to 1939 will be connected with tidewater by a 260-mile 12-inch pipe line with a terminus at the port of Carenas. On the Barco concession 2 fields were discovered in the past and were extended during 1938, the Petrolia having 17 producing wells and the Rio de Oro 3 producing wells with a combined estimated potential of about 58,000 barrels.

With the granting of additional concessions geophysical, geologi-

cal, and drilling exploration work will continue very active in Colombia in the next few years, being concentrated in the Magdalena Valley, though preliminary work is now beginning in the Llanos of eastern Colombia. With completion of the new pipe line the production of Colombia should increase to 30,000,000 barrels during 1939 and if the fields of the Barco concession come up to expectations Colombia should produce approximately 40,000,000 barrels per year beginning with 1940.

TRINIDAD

Production in Trinidad during 1938 reached an all-time record, averaging 48,595 barrels per day, an increase of 14.41 per cent above 1937, and by the end of the year production was slightly in excess of 50,000 barrels per day. The most important developments of 1938 were associated with the Guapo fault zone in which the Coora and Los Bajos fields, now 7 miles apart, may possibly meet. At the end of the year exploration by drill started in the North Basin on 2 structures worked out by the seismograph with the tests scheduled to go to 10,000 feet.

With reserves already proved the production of Trinidad may be expected to continue at about the present levels with slightly upward trend for a number of years.

ARGENTINA

There were no developments of importance in Argentina during 1938 but the reserves already proved assure the country of the present rate of production for several years without appreciable decline, though a considerable increase is not now in sight.

PERU

The fields of the northwestern coastal area continued to supply all production of Peru during 1938. La Brea-Parinas remained the most important producing field, accounting for 83 per cent of the total production, followed by Lobitos which produced the remaining 17 per cent, while Zarritos produced a nominal amount of 40,000 barrels during the whole year. Early in 1939 a possibly important discovery was made at Agua Caliente on the Pachitea River east of the Andes. The discovery well was completed in February with initial production of about 1,000 barrels per day of 45° gravity oil from 1,175 feet in the Cretaceous. The remote location of the discovery, however, practically precludes its exploitation at anywhere near the current crude oil prices and it is currently therefore more of academic than of practical

interest and should not affect the production of Peru for many years to come.

BRITISH INDIA AND BURMA

There were no developments of consequence in British India and Burma during 1938 but the reserves in sight assure this province of about the present rate of production for a number of years.

BAHREIN ISLAND AND SAUDI ARABIA

During 1938 production of Bahrein Island and Saudi Arabia averaged 24,090 barrels per day, a nominal increase over that of the preceding year, the output being limited by the available market outlets. Bahrein Island at the end of 1938 had 52 oil wells producing from Senonian (?) limestone of Cretaceous age at about 2,300 feet, crude oil being of 32° gravity. On the mainland of Saudi Arabia the Dammam field was further extended during 1938 and as the year ended a pipe line was being completed from Dammam to Ras Tanura on the Gulf of Iran and this field should begin moving its production during the second half of 1939. Important exploration work, including drilling operations, was in progress at Abu Hadriya, located about 100 miles northwest from Dammam. Extensive geological and geophysical exploration work will be in all probability continued on the large concession of the California Arabian Standard Oil Company in Saudi Arabia and the production from this province should show considerable increase during the coming years.

SARAWAK AND BRUNEI

There were no developments of importance in the British East Indies during 1938, but the reserves in sight assure this area of continuation of the present rate of production for several years to come.

CANADA

A very large increase took place in the production of Canada during 1938, its output averaging 19,033 barrels per day during 1938 as compared with an average of 8,206 barrels produced in 1937, an increase of 131.95 per cent. The Turner Valley field was responsible for the increase in production, averaging 18,332 barrels per day in 1938 as compared with 7,580 barrels in 1937. Production in Turner Valley is derived from the 2 porous zones in the upper 450 feet of the Madison dolomitic limestone of Mississippian age, production in which was proved in 1924 but from which only gas and condensate have been produced until 1936 when heavier crude oil was found in

the same zone on the west flank of this structure. Turner Valley is a large fold cut off on the east side by an overthrust fault. By the end of 1938 there were 65 oil wells and 104 gas wells in the Turner Valley field, with a potential production of about 50,000 barrels per day. The producing area of the west flank of the Turner Valley is divided into north and south parts, the proved acreage of the south area being approximately 5 miles long by 2 miles wide and the proved acreage of the north area being approximately 2½ miles long and as yet of undetermined width. The two areas, now 10 miles apart, may feasibly connect though the oil-producing area may be but one location wide and hence difficult to explore. The proved reserve of the Turner Valley field has been estimated by various authorities at between 125,000,000 and 150,000,000 barrels. Elsewhere in the prairie provinces of Canada active exploration continued but no promising results were obtained.

Production of Canada should continue at 20,000–30,000 barrels per day for a number of years inasmuch as the Turner Valley crude-oil production is limited by local market outlets and can not compete with cheaply producible oil of the United States which is available on the Pacific Coast of Canada and in the eastern provinces of the Dominion.

GERMANY

During 1938 the oil fields of greater Germany, which now includes former Austria and Czecho-Slovakia, produced an average of 12,047 barrels per day as compared with an average of 9,693 barrels during 1937, or an increase of 24.28 per cent. The Nienhagen field accounted for about 60 per cent of the total production, increasing 3.5 per cent above its 1937 output, the remaining fields producing nominal amounts. The exploration for oil in Germany is being heavily subsidized by the Government in an attempt to make the country self-sufficient in case of international conflict since currently it is able, even including production of synthetic liquid fuels, to provide but 10 per cent of the national requirements. In 1938 a possibly important field was discovered at Reitdebrook near Hamburg but in general the outlook for Germany to become self-sufficient is far from promising.

POLAND

There were no developments of any importance in Poland in the past few years and the fields of this country can be considered as being in the stripper class. Most of the older fields are currently being repressured, reportedly with good results. In northwest Poland in the

province of Pomerze 3 salt domes are to be explored shortly in which oil showings have been reported in the salt mines. Some geophysical work is being undertaken in other provinces of Poland but on the whole the outlook for discoveries is poor.

EGYPT

Production in Egypt averaged 4,151 barrels per day during 1938 as compared with 3,126 barrels per day in 1937, an increase of 32.7 per cent due to the development of the Bas Gharib field discovered in 1938. The only other field in Egypt, Hurghada, showed a slight decline in 1938, averaging in that year 2,740 barrels per day, producing from a depth of about 1,600 feet from the Nubian sandstone of the Cretaceous. A large number of concessions have been granted to foreign oil interests in Egypt during 1938 and an extensive geophysical and geological exploration campaign is now under way and consequently the production of Egypt may be expected to show appreciable increase in the coming years.

HUNGARY

The Budafa-Puszta field, discovered in 1937, was producing in December of that year 1,400 barrels per day or about 33 per cent of the country's requirements. Seven wells have been completed in the Budafa-Puszta field to a depth of about 4,100 feet with initial production ranging from 150 to 400 barrels per day. The proved area of the field is currently estimated at 1,200 acres. A deep test was drilled on this structure in 1938 to 8,226 feet with negative results. The Bukkszek field, also discovered in 1937, remained an unimportant prospect, producing from fissured andesite tuff interbedded with shales on an extremely faulted structure. While some encouraging results have been obtained in Hungary within the last 2 years no large fields are as yet in sight.

OTHERS

In South America exploration is under way with promising indications in both Brazil and Bolivia but no definite results have been obtained. In Cuba extensive exploration work has been undertaken, encouraged by favorable legislation, but as yet production of the island is nominal and nothing of great promise is in sight.

In Great Britain the exploration for oil, greatly encouraged by the Government with a view to providing for national emergencies, has been most active during the past 2 years and much detailed geological and geophysical work was done, but the results of drilling exploration

to date have been entirely negative, even though a number of deep tests have been drilled in several of the most promising localities. The extent of the effort can be judged by the fact that at one time 26 per cent of the area of England, Scotland, and Wales was under prospecting licenses.

In Africa further geological investigations and some nominal exploration work continued in the northern provinces without any promising results whatsoever.

In Australia the search for oil continued with government assistance but nothing but non-commercial showings have been encountered so far.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
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REVIEWS AND NEW PUBLICATIONS

* Subjects indicated by asterisk are in the Association library and available to members and associates.

RECENT PUBLICATIONS

AFRICA

*"The Early Cretaceous Valley-Floor Peneplain of the Lake Nyasa Region and Its Relation to Tertiary Rift Structures," by Frank Dixey. *Quar. Jour. Geol. Soc. London*, Vol. 95, Pt. 1 (March 22, 1939), pp. 75–108; 3 figs., 1 pl.

ALBANIA

**Guide to a Trip from Durazzo through Berat and the Devoli Basin to Valona*, by S. Zuber. 16 pp., 4 pls., showing stratigraphy, structure, paleogeology. Published by Azienda Italiana Petroli Albania ("A.I.P.A."), Italian Ministry of Communications, Rome (1938). In Italian.

CALIFORNIA

*"Evidence of the Age of a Crystalline Limestone in Southern California," by Robert W. Webb. *Jour. Geol.*, Vol. 47, No. 2 (Chicago, February–March, 1939), pp. 198–201.

COLOMBIA

*"Geology of Middle and Upper Magdalena Valley," by John W. Butler, Jr. *World Petroleum*, Vol. 10, No. 3 (New York, March, 1939), pp. 95–100; stratigraphic correlation chart, 2 geologic sections. In *World Petroleum* feature number on Colombian oil, containing folded insert oil map of Colombia in colors, showing company holdings, oil fields, physiographic features, and culture.

"A Devonian Fauna from Colombia," by Kenneth E. Caster. *Bull. Amer. Paleontology*, Vol. 24, No. 83, pp. 1–184; 14 pls.

COLORADO

*"Guide to the Geology of the Golden Area," by F. M. Van Tuyl, J. Harlan Johnson, W. A. Waldschmidt, James Boyd, and Ben H. Parker. *Colorado School of Mines Quarterly*, Vol. 33, No. 3 (Golden, July, 1938). 32 pp., 10 figs., 1 pl. (folded map in pocket, showing geology and topography of the Golden area in colors). Dept. of Geology, Colorado School of Mines, Golden. Price, $0.50.

Geologic Map of Wilson Creek Dome, Rio Blanco and Moffat Counties, Colorado, by W. B. Kramer, Robert McMillan, and P. W. Guild, under supervision of C. E. Dobbin. A few copies available free at U. S. Geol. Survey, Washington, D. C., and at 224 U. S. Customhouse, Denver, Colorado.

ENGLAND

*"The Stratigraphy of the Wenlock Limestone of Dudley," by Arthur James Butler. *Quar. Jour. Geol. Soc. London*, Vol. 95, Pt. 1 (March 22, 1939), pp. 37–74; 13 figs., 1 pl.

GENERAL

*A *Catalogue of the Ammonites of the Liassic Family Liparoceratidae in the British Museum (Natural History)*, by L. F. Spath. 191 pp., 26 pls., 17 text figs. Outside dimensions, approx. 10×11.5 inches. Cloth. The British Museum, Cromwell Road, London, S.W. 7. Price, £1, 10s.

*"The Origin and Correlation of the Cloverly Conglomerate," by Edward C. H. Lammers. *Jour. Geol.*, Vol. 47, No. 2 (Chicago, February–March, 1939), pp. 113–32; 2 figs.

*"The Geology of the Southern Alps," by L. U. de Sitter, *Geologie en Mijnbouw*, Vol. 1, New Ser., No. 4 (The Hague, April, 1939), pp. 68–91; stratigraphic charts, geologic maps and sections. In French.

Economics of the Petroleum Industry, by Joseph E. Pogue. 60 pp., charts, diagrams, tables. Paper. Published by the Chase National Bank, New York (1939). This is one chapter of a book to be published as *The Elements of the Petroleum Industry*.

**Annotated Bibliography of Economic Geology for 1938*, Vol. 11, No. 1 (February, 1939). 208 pp. Published by Economic Geology Publishing Company, Urbana, Illinois. Annual subscription, $5.00.

GEOPHYSICS

**Polar Core Orientation*, by Dwight C. Roberts and E. Ray Webb. Paper presented at the technical meetings during Oil World Exposition at Houston, Texas, April 24–29, 1939. 15 pp., 9 figs. Sperry-Sun Well Surveying Company, Philadelphia, Pennsylvania (1939).

*"Gravimeters: Their Relation to Seismometers, Astatization, and Calibration," by C. A. Heiland. *A.I.M.E. Tech. Pub. 1049* (New York; April, 1939). 26 pp., 15 figs.

*"Seismograph Prospecting for Oil." A symposium containing: "Introduction," by Walter A. English; "Theory of Seismic Reflection Prospecting," by Willard H. Tracy; "Instruments for Reflection Seismograph Prospecting," by Arthur Nomann; "Seismograph Field Operations," by Frank Ittner; "Determining Geologic Structure from Seismograph Records," by P. C. Kelly. *Ibid. 1059*. 29 pp.

*"Exploring Drill Holes by Sample-Taking Bullets," by Eugene G. Leonardon and D. C. McCann. *Ibid. 1062*. 13 pp., 10 figs.

KANSAS

*"Geology and Oil and Gas Resources of Logan, Gove, and Trego Counties, Kansas," by Kenneth K. Landes and Raymond P. Keroher. *Kansas Geol. Survey Mineral Resources Cir. 11; Bull. Univ. Kansas*, Vol. 40, No. 4 (February 15, 1939). 45 pp., 8 figs., 4 pls.

**Oil and Gas Exploration Map, Labette County, Kansas*, by G. E. Abernathy. Single sheet, 23×36 inches. Shows location and status of wells, location of pipe lines, and stratigraphic depth of wells in colors; also a geologic section, east-west, across the county. Reverse of sheet bears descriptive text on "Oil, Gas and Coal in Labette County, Kansas," with a generalized rock section. Published by State Geological Survey, Lawrence, Kansas (1939).

LOUISIANA

*"Louisiana Cook Mountain Eocene Foraminifera," by Henry V. Howe. *Louisiana Geol. Survey Bull. 14* (New Orleans, 1939). 122 pp., 2 tables, 15 pls.

NEVADA

*"The Miocene Humboldt Formation in Northeastern Nevada," by Robert P. Sharp. *Jour. Geol.*, Vol. 47, No. 2 (Chicago, February–March, 1939), pp. 133–60; 9 figs.

POLAND

*"Senonian Stratigraphy along the Weichsel River between Rachów and Pulawy in Central Poland," by Wladyslaw Pozaryski. *Poland Geol. Survey Bull. 6* (Warsaw, 1938). 94 pp., fossil time table, correlation charts, geologic map, and cross section. In Polish. Summary in German (pp. 63–94).

*"Flora and Stratigraphy of the Ruda Beds in the Vicinity of Katowice," by Stanislaw Zb. Stopa. *Ibid., Bull. 7* (Warsaw, 1938), 18 pp., 5 tables, 1 fig. In Polish. Résumé (pp. 15–18) in French.

*"Geologic Research in the Vicinity of Blazowa (Carpathians)," by Jan Wdowiarz. *Geol. Soc. Poland*, Vol. 14 (Kraków, 1938), pp. 45–57; 1 fig., 1 folded geologic map with topographic contours in red. In Polish. Résumé in French (pp. 55–56).

*"Microfauna from the 1936–1937 Drilling Operations of 'Pionier A. G.' in the Carpathian Foreland," by Wilhelm Friedberg. *Ibid.*, pp. 58–80. In Polish. Summary in German (p. 80).

*"Paleogeography of Roztocze near Lwów," by Henryk Teisseyre. *Ibid.*, pp. 113–54; 8 figs. In Polish. Résumé in French (pp. 144–50).

*"The Dniester River and Tortonian Gypsum," by Jan Nowak. *Ibid.*, pp. 155–94; 5 figs. In Polish. Summary in German (pp. 193–94).

TEXAS

*"Oil Development and Production Practices in Southwest Texas," by C. H. Row and R. H. McLemore. *Oil and Gas Jour.*, Vol. 37, No. 45 (Tulsa, March 23, 1939), pp. 89–97; 2 figs., 3 tables, map.

Structural Map of Texas. 1939 edition. Scale, 1:1,000,000; contours, 50-foot interval. Bureau of Economic Geology, University of Texas, Austin. Prices: paper, $1.00; mounted on cloth, rolled, $1.75; cut, mounted, and folded to size 10.5×13 inches, $2.50.

"Stratigraphic and Structural Studies of the Pennsylvanian and Permian Rocks in North-Central Texas," by Wallace Lee *et al. Univ. Texas Bull. 3801.* 252 pp., 11 pls., 9 figs. Price, paper, $1.50.

"The Geology of Leon County, Texas," by H. B. Stenzel. *Ibid., Bull. 3818.* Approx. 170 pp., 61 figs., geologic map in colors (scale, 1:96,000). In press. Price, paper, $1.00.

VENEZUELA

**Boletin de Geologia y Mineria*, Vol. 2, Nos. 2, 3, 4 (April, July, October, 1938). 302 pp. Vol. 2 of the Venezuela Geological Survey, Caracas, contains 14 papers presented before the second Venezuelan Geological Congress, at San Cristóbal, April, 1938, with additional notes, appendices, *et cetera*. A map pocket contains a geological sketch map of the western Venezuelan Andes, by Kehrer and Kundig (folded, in colors); a topographic map of the state of Tachira (folded); and a map of the Trans-Andes Highway (folded). The papers are published in Spanish (302 pp.) and on English edition.

"Geological History of the South American Cordilleras," by H. Gerth, pp. 1–10.

"Stratigraphy of the Cretaceous Formations in the Carache River Valley, Trujillo," by W. C. G. Tomalin, pp. 11–20; 3 figs.

"Pre-Cretaceous Rocks of the Central Andes of Venezuela with Notes on Tectonics," by F. Kundig, pp. 21–43; 1 geologic section in colors.

"Notes on the Stratigraphy of the State of Tachira," by L. Kehrer, pp. 44–56; 1 geologic section in colors.

"Additional Notes on the Stratigraphy of the Upper Tertiary Formations in the Coastal Region of the Bolivar District, State of Zulia," by G. Edward Manger, pp. 57–81.

"Reserves of Fresh Water in the Coastal Region of the Bolivar District, State of Zulia," by John G. Douglas, pp. 82–102; 4 water analysis charts and an index map.

"Aspect and Division of Molluscan Faunal Zones in the La Rosa and Lagunillas Formations of the Coastal Fields of Bolivar," by Wm. S. Hoffmeister, pp. 103–122; 1 stratigraphic section.

"Contribution to the Study of the Zulia-Falcon Sedimentary Basin," by Clemente González de Juana, pp. 123–38; 3 figs.

"Geology of the Region of 'El Valle de Guanape,' Bruzual District, State of Anzoategui," by K. F. Dallmus, pp. 139–50; 1 map.

"Geology of the Island of Gran Roque and Its Phosphate Deposits," by S. E. Aguerrevere and V. M. Lopez, pp. 151–80; 21 figs.

"Pre-Cretaceous Rocks in the State of Barinas," by M. M. Knechtel, pp. 181–84; 1 fig.

"Geologic Notes on the Oil Field of Quiriquire, Piar District, State of Monagas," by J. H. Regan, pp. 185–200; 2 geologic sections, 1 structure-contour map.

"The Eocene of Soldado Rock Near Trinidad," by H. G. Kugler, pp. 201–25; 2 photographs, 4 geologic sections, 1 geologic map.

"Note on the Cretaceous of Trinidad," by A. G. Hutchison, pp. 226–36.

WISCONSIN

*"Wisconsin Silurian Bioherms (Organic Reefs)," by Robert R. Schrock. *Bull. Geol. Soc. America*, Vol. 50, No. 4 (New York, April 1, 1939), pp. 530–62; 4 figs., 2 pls.

ASSOCIATION DIVISION OF PALEONTOLOGY AND MINERALOGY

**Journal of Sedimentary Petrology* (Tulsa, Oklahoma), Vol. 9, No. 1 (April, 1939).

"Bacterial Counts in the Muds of Crystal Lake," by Philip L. Carpenter

"Shoal-Water Deposits of the Bermuda Banks," by Jean P. Todd

"The Occurrence of Spore Coal in the Williamston Basin, Michigan," by S. G. Bergquist

"Igneous and Metamorphic Rocks from Pleistocene Gravels of Central Louisiana," by H. N. Fisk

"Sorting and Transportation of Material in the Swash and Backwash," by O. F. Evans

"Varve-like Deposit in a Solution Channel," by W. D. Keller

"Types and Sources of Sediments Deposited by the South Canadian River in New Mexico and Texas," by Raymond Sidwell

**Journal of Paleontology* (Tulsa, Oklahoma), Vol. 13, No. 3 (May, 1939).

"Silurian Fossils from Northern Newfoundland," by R. R. Shrock and W. H. Twenhofel

"Eocene and Paleocene Turritellidae of the Atlantic and Gulf Coastal Plain of North America," by Edgar Bowles

"Equivalence of the Gosport Sand to the Moodys Marl," by C. Wythe Cooke

"Recent Collections of Upper Eocene Mollusca from Alabama and Mississippi," by Julia Gardner

"Permian Fusulines from Central America," by Carl O. Dunbar

"A Cranium of *Pliohippus fossulatus* from the Clarendon Lower Pliocene Fauna of Texas," by R. A. Stirton and Will Chamberlain

"*Arca* (*Noetia*) *veatchites*, new name for *A.* (*N.*) *veatchi* Caster, 1938," by Kenneth E. Caster

"*Linobrachiocrinus*, new name for *Linocrinus* Goldring, not Kirk, 1938," by Winifred Goldring.

"Fresh-water Invertebrates and Land Plants of Cretaceous Age from Eureka, Nevada," by F. Stearns MacNeil

"Dinosaur Tracks in the Lakota Sandstone of the Eastern Black Hills, South Dakota," by Sumner M. Anderson

"*Phlaocyon*—A Correction," by Paul O. McGrew

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THE ASSOCIATION ROUND TABLE

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The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute an election but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to the Executive Committee, Box 979, Tulsa, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

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BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE, 1939), PP. 978-979

RESEARCH NOTES

SURVEY OF RESEARCH OPINION

STANLEY C. HEROLD[1]
Glendale, California

A critical examination of the opinions of members with respect to research in petroleum geology, such opinions as were published in this *Bulletin*, Volume 23, Number 3, for March, 1939, reveals the inclinations of the contributing members and gives rise to several questions which seem to have a bearing upon the paths we are to define for future research.

In all there were the opinions of 102 members published. These, we assume, were considered of prime importance by the research committee according to the report of its chairman. Some 66 of these opinions refer to subjects ordinarily accepted as matters properly included in the study of petroleum geology. Specifically these subjects relate to origin, source beds, paleogeography, petrology, lithology, sedimentation, deposition, electrical logging, paleontology, ecology, structure, stratigraphy, and metamorphism. Furthermore, the sciences of biochemistry, geochemistry, physical chemistry, and geophysics are included in this group. Not many of the components of petroleum geology are omitted. The profession appears to be in a healthy state, for there is at least one member who is dissatisfied with our present knowledge of almost any topic that can be mentioned, and it is likely that each one who expressed his opinion can find many others that feel the same way, others who did not express their opinions in the survey.

Apparently much yet remains to be accomplished in petroleum geology; there is still opportunity for the generation just now entering the profession. One who believes that the Association should confine itself to geology can well say that there is no deficiency of matters for research in geology, and that therefore the need to encroach upon allied professions is non-existent.

One or two members suggested the need for research in such a broad economic factor as supply and demand. But clearly this is not geology, and this fact seems well appreciated, else there would have been more frequent mention of it. The same may be said of such a subject as the history of petroleum. Surely if any petroleum geologist wishes to specialize on these topics his writings will be read widely. They are of interest; they require minds not too thoroughly steeped in matters pertaining to natural phenomena, but given more to the consideration of relations between these phenomena and the behavior of human beings.

About 34 of the 102 members called for research in subjects which fundamentally refer to reservoir mechanics. Migration, accumulation, well spacing, reserves, ultimate recovery, percentage recovery, repressuring, pressure maintenance, gas energy, edge waters, reservoir performance, well performance, bottom-hole pressures, porosity, and permeability were specifically mentioned.

Do these topics pertain to geology? Do they pertain to petroleum geology? One fact is clear: approximately one-third of the group which expressed

[1] Consulting geologist. Manuscript received, April 3, 1939.

opinions are required to consider matters concerning the reservoirs and wells in their routine duties of service to their clients. More to the point perhaps is this question: is the Association to abide by its preamble and consequently encourage research in matters not acceptable to all members as subjects of petroleum geology?

As to those who are suggesting research in reservoir mechanics, exactly what is it they want? Are they not aware of the fact that practically all of the subjects mentioned have been studied for some time past, and are being studied today, by petroleum engineers? Undoubtedly they know this. Then is it to be understood that they are not pleased with the research? Can it be that the method of approach is unsatisfactory. That seems probable.

A geologist in his work observes a set of conditions in a specific region and thereafter proceeds to generalize for all regions which appear to have any characteristics of similar nature. This is the method of induction. In contrast an engineer begins with accepted physical laws and proceeds to compute what should happen under specified conditions. Having his solution he then examines the data of his observations to see if they bear a favorable relation to each other. This is the method of deduction. One of the members says he wants the deductive approach replaced by the inductive approach, at least in the problem of accumulation, which happens to be his subject of mechanics holding first importance. Very well, there are many geologists who believe likewise. And this being the case, should the Association not promote research in the subject of research to determine the choice between inductive and deductive reasoning as applied to research? This may sound like nonsense, but it is not. How frequently in past meetings, when questions have been raised regarding any of the topics in reservoir mechanics, someone arose to suggest the appointment of a committee to collect the necessary data and interpret them. We have several such outstanding committees today. If we should be able to know in advance whether or not this induction by the collection of data is the proper procedure, then we would be able to cut down at least by one-half the research now being carried on. The time, the effort, and the money being spent on an incorrect approach can be applied to a correct one.

Of course we may find on investigation that petroleum geologists will never accept the results of deductive reasoning, and likewise, that petroleum engineers will never accept the results of inductive reasoning. In that case we must encourage both approaches. One advantage in the double approach appears likely; namely, we shall recognize the proper solution to problems by the fact that the two methods lead to the same results. If this is a criterion of good work it is evident that up to the present time we can not have many right answers. Some 34 members appear not satisfied with the solutions now at hand.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 23, NO. 6 (JUNE, 1939), PP. 980-982

AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

WILLIS STORM, president of the South Texas Geological Society, of San Antonio, has announced appointment of the following committee chairmen for the current year: program, JOSEPH M. DAWSON, Gulf Oil Corporation, San Antonio; oil-field nomenclature, J. M. HANCOCK, Union Producing Company, Beeville; museum, FELIX A. VOGEL, San Antonio; membership, P. A. MEYERS, Pan American Production Company, Corpus Christi; entertainment, DUNBAR A. FISHER, Humble Oil and Refining Company, Corpus Christi; operations, THORNTON DAVIS, Peerless Oil and Gas Company, San Antonio. The Society has 226 members.

EMMETT L. ARNOLD, formerly at La Feria, Texas, may be addressed at Cristobal, Canal Zone, Post Office Box 1572.

The Society of Economic Geologists will hold a summer meeting, August 8–10, at Berkeley, California, in conjunction with the Geological Society of America, under the auspices of the Cordilleran Section. CARLTON D. HULIN, Bacon Hall, University of California, Berkeley, California, is chairman of the local committee.

H. FOSTER BAIN is mining adviser of the Bureau of Mines at Manila, Philippine Islands.

ALEX W. MCCOY, consulting petroleum engineer, Ponca City, Oklahoma, a past-president of the Association, talked on the subject, "An Interpretation of Petroleum Reserves," at the annual president's dinner meeting of the Mid-Continent Section of the A.I.M.E., at Tulsa, May 10.

WILSON M. LAIRD, of the department of geology, University of Cincinnati, Cincinnati, Ohio, is working in the field this summer on a study of the Upper Devonian in southwestern Pennsylvania and its relationship to similar stratigraphic units in northwestern Pennsylvania, West Virginia, and Maryland. Laird was awarded a grant-in-aid made available by the Pittsburgh convention committee of the mid-year meeting of the Association in October, 1937. M. GORDON GULLEY, Gulf Oil Corporation, Pittsburgh, represents the trustees of the fund.

W. I. INGHAM, consulting geologist of Tulsa, is in Kentucky this summer engaged in surface geology for the Gulf Oil Corporation.

ARTHUR R. MAY, geologist with the Shell oil group for the past 20 years, is with the Superior Oil Company at Bakersfield, California.

H. RIES, professor of geology, Cornell University, is retiring after having served as head of the department for 23 years. C. M. NEVIN, professor of geology, has been appointed chairman.

F. H. LAHEE, as representative of the Association, attended the meeting of the Division of Geology and Geography of the National Research Council on April 28 and April 29 in Washington, D. C. His report on this meeting will be submitted to the Association next March.

H. C. BECKER, recently with the Seismograph Service Corporation, Tulsa, Oklahoma, is in the employ of the Barnsdall Oil Company, 2212 Esperson Building, Houston, Texas.

IVAN M. GOUBKIN, president of the geological committee for the U.S.S.R. government, died on April 21, at Moscow.

L. M. CLINE, of the Iowa State College and the Iowa Geological Survey, addressed the Tulsa Geological Society, May 15, on "The General Geology of Southern Iowa."

The annual meeting of the Field Conference of Pennsylvania Geologists was held at Morgantown, West Virginia, at the invitation of the West Virginia Geological Survey, May 27–30.

A. M. LLOYD, district geologist for the Sun Oil Company, talked on "Surface Geology of Vernon and Rapides Parishes," before the Shreveport Geological Society, May 18.

EUGENE VANDERPOOL, of the Stanolind Oil and Gas Company, has been transferred from Fort Worth to Midland, Texas.

LINN M. FARISH is in the geological department of the Magnolia Petroleum Company, Dallas, Texas.

DON O. CHAPELL and R. L. ROBERTS have been transferred from Mattoon, Illinois, to Kalamazoo, Michigan, where the Transwestern Oil Company has established its eastern division offices.

ELLEN POSEY BITGOOD, formerly with the Cities Service Oil Company, is district geologist at Wichita Falls, Texas, for the Superior Oil Company of California.

The Abilene Geological Society was recently organized at Abilene, Texas. The officers are: president, RILEY G. MAXWELL, Merry Brothers and Perini; vice-president, CARL S. SHOULTS, independent geologist; secretary-treasurer, EUGENE F. BOEHMS, Forest Development Company, all of Abilene.

A. E. GETZENDANER and JOHN CLAYTON, of the geological department of the Gulf Oil Corporation, have moved from Corpus Christi to Houston, Texas.

The West Texas Geological Society of Midland, Texas, held its spring field trip, May 19–21, in the vicinity of Van Horn, Texas, to study stratigraphic sections in the Sierra Diablo, Beach, and Baylor mountains.

The Appalachian Geological Society recently met at Ashland, Kentucky, with an attendance of about 60. Principal speakers were: LOUISE MARTIN FREEMAN of the Kentucky Department of Mines; DANIEL J. JONES, State geologist of Kentucky, and ARTHUR C. MCFARLAN, head of the department of geology at the University of Kentucky.

HERSCHEL H. COOPER, consulting geologist of San Antonio, Texas, is a member of the board of directors of the Groos National Bank of San Antonio.

CYRIL K. MORESI, State geologist of Louisiana, has a 6-page article, "The School of Geology of the Louisiana State University and Louisiana Geological Survey," in the Spring number of the *Louisiana Conservation Review* (New Orleans, May, 1939). Deserved praise is given HENRY V. HOWE, director of the school and director of the Survey, for his work in Louisiana since appointment as professor of geology in 1922.

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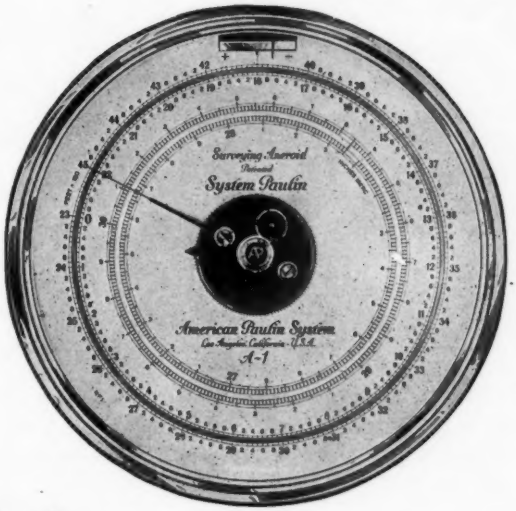

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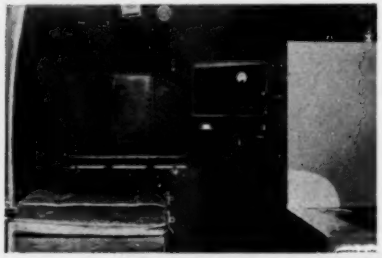

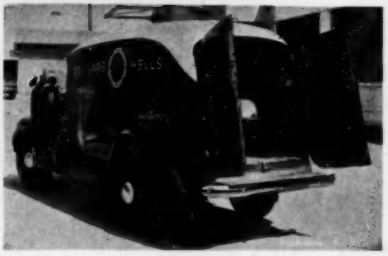

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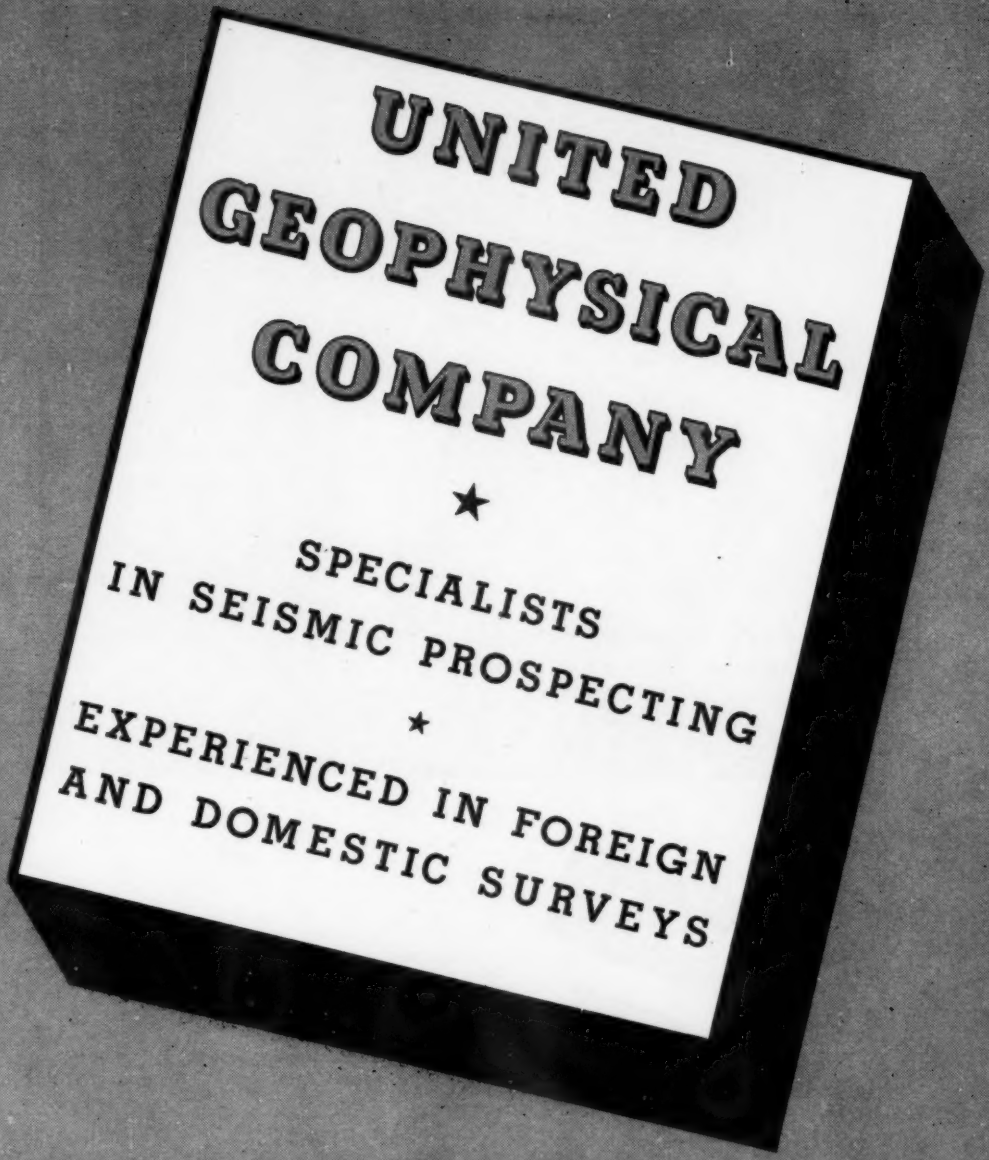

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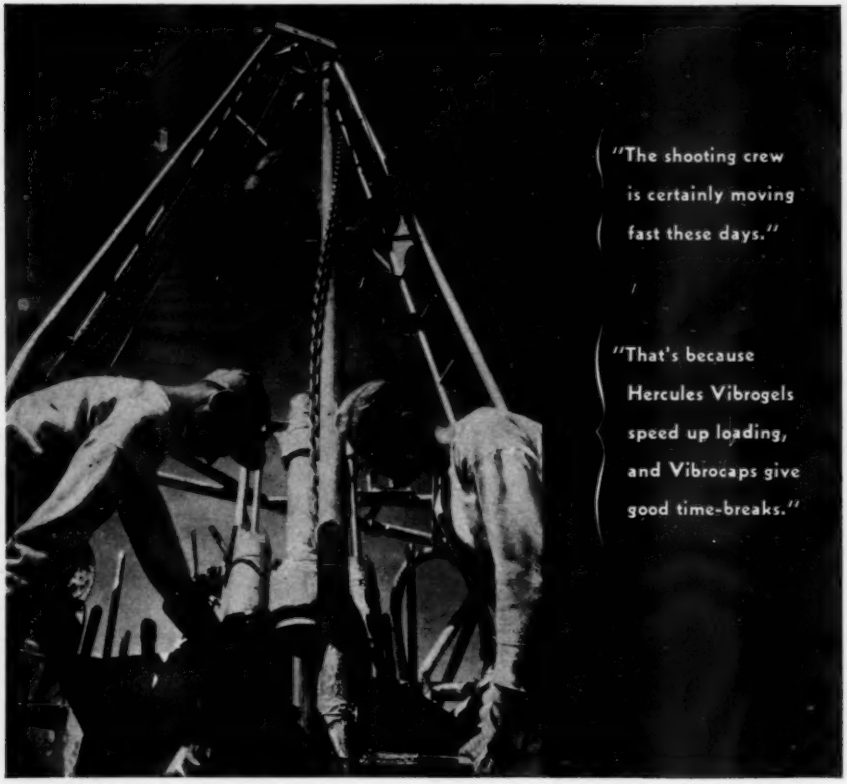
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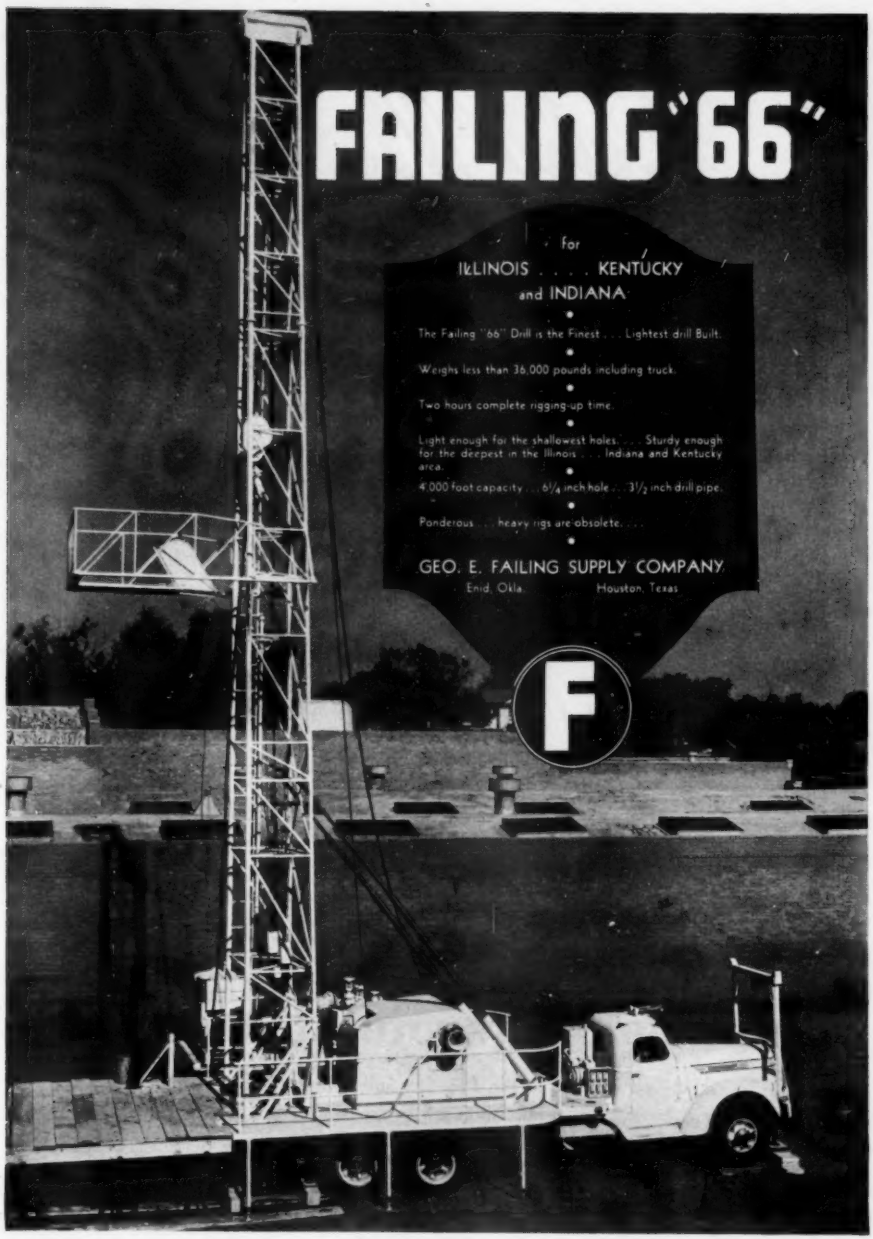
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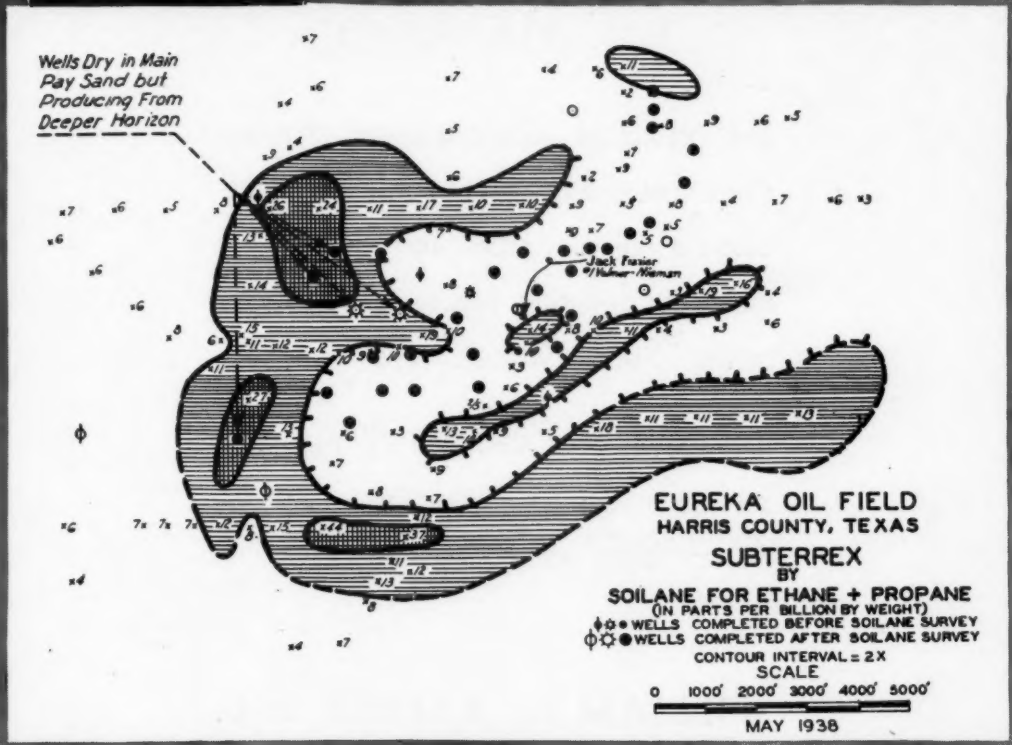
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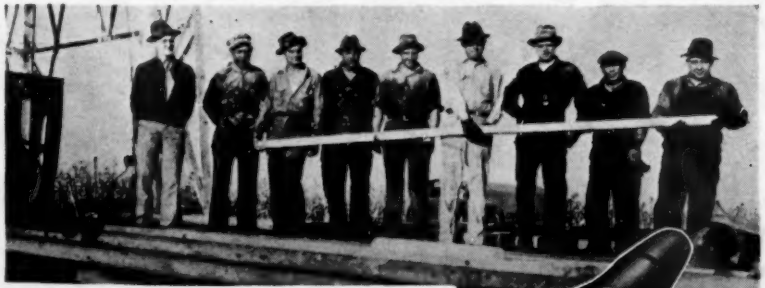

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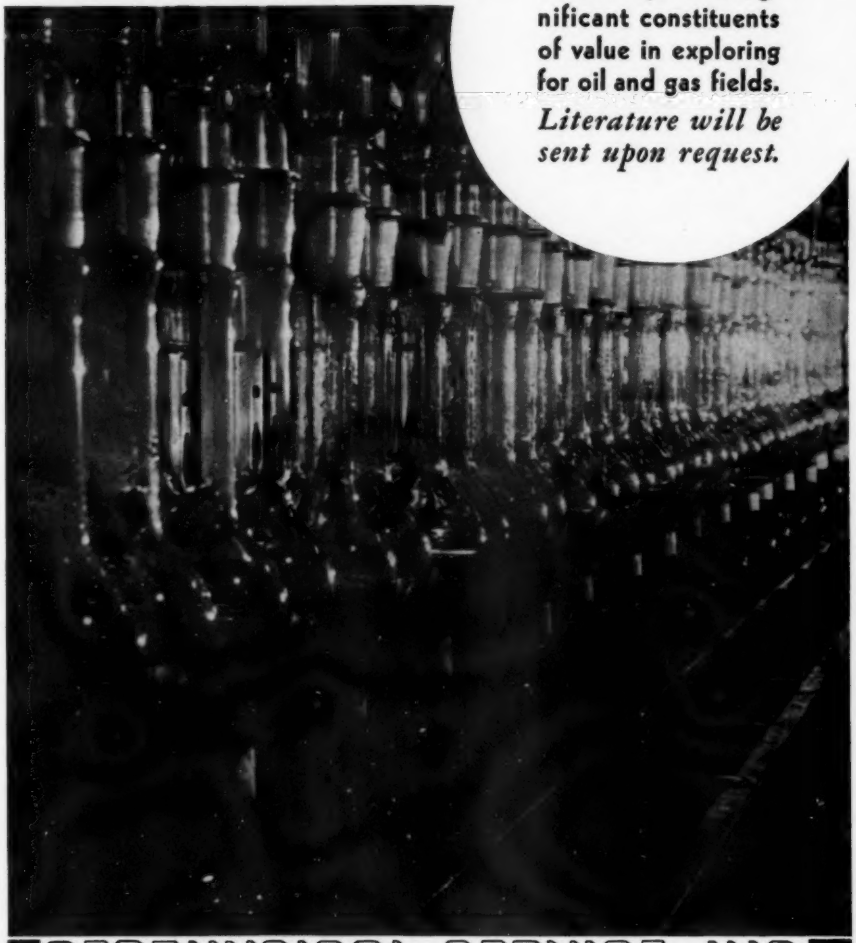

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